Texas Transportation Institute

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TECHNICAL MEMORANDUM

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SUBJECT: **Task 1.0 – Needs Analysis**

The purpose of this technical memorandum is to summarize the activities related to Task 1 of the Planning Analysis Tools for Operational/Intelligent Transportation System (ITS) Evaluation Gap Study. The purpose of this task was to identify the needs of state departments of transportation (DOT) and metropolitan planning organizations (MPO) for evaluating operations and ITS projects in the planning process. This was accomplished through the following:

- A review of the pertinent literature,
- An assessment of the procedures that State DOT's and MPO's use in evaluating and selecting projects for inclusion in the TIP, and
- A one-day focus group workshop.

Using the results of literature review, the assessment of procedures, and the workshop, we developed a taxonomy of user needs for evaluating operations-oriented and ITS projects.

LINKING PLANNING AND OPERATIONS LITERATURE

The Transportation Equity Act for the 21st Century (TEA-21) identifies seven factors that agencies must consider in the planning process. One of those factors is that transportation plans "promote efficient system management and operations."

One of the first major efforts to examine linking operations and planning was the *21st Century Transportation Symposium: Linking Regional Planning and Operations for Effective ITS Deployment* (*1*). The purpose of this symposium was to begin a dialogue on how planning and operations can be linked to improve the efficiency of the transportation network. Some of the major recommendations from the speakers at the symposium were as follows:

- In order to have successful deployments of ITS and other operation-oriented projects, there needs to be closer coupling of planning and operations. Planners and operators need to learn a common language, and share resources and data.
- Funding for ITS and operations-oriented projects will be difficult. There are limited funds and ITS and operations-oriented projects will have to compete for a finite amount of funding.
- ITS and operations-oriented projects are regional in nature. The current processes and procedures for securing funding for projects place operations and ITS projects at a competitive disadvantage. There needs to be a change from a planning culture that is project-oriented to one that is "program" oriented.

- There needs to be a balance between implementing strategies to improve system efficiency and adding new capacity. Neither approach by itself will solve the congestion problems. Both are needed if true improvements in system performance are desired.

In October 2001, the National Steering Committee on Transportation Operations and the Federal Highway Administration hosted a National Summit on Transportation Operations(*2*). The goal of the Summit was to identify and discuss needs, opportunities, and strategies necessary to enhance transportation operations from the perspective of public- and private-sector stakeholders. One issue specifically addressed in the Summit was creating linkages between the traditional capital planning process and planning for operations. Some of the recommendations from the Summit dealing with planning for operations are listed below:

- Establish linkages between operations, and land use and development programs.
- Incorporate operations into the decision-making processes.
- Develop metrics based on internal and region wide goals.
- The planning process should be based on system performance rather than capital projects.
- Operations planning should define participants, outcome functions, and timing of activities.
- Operations planning should identify projects, activities, and policies to improve options, choice, and redundancy at the system level.

Some of the benefits cited for linking planning and operations include the following (*3, 4, 5*):

- Improved ability to address both short-and long-term transportation needs in a region.
- A more region-oriented approach for addressing transportation needs as opposed to the traditional parochial approach common in many locales.
- Increase overall reliability and predictability of trip times for traveler and freight providers;
- Better fiscal responsibility through the use of resource and data sharing;
- Improved intra- and interagency communications.
- Improved emergency preparedness due to increased flexibility by insuring the security of critical transportation elements.

One big drawback cited for linking planning and operations is the difficulty agencies have quantifying the benefits of ITS and operations-oriented projects. (*3*) Many agencies complain that there is little to no quantitative data that show the effectiveness of operations improvements, especially from a regional perspective. Others complain that the analysis tools are more oriented towards calculating the benefit of major infrastructure investments and not operation-oriented or ITS benefits. These tools also do not adequately capture the effects of region-wide operations programs and management strategies used to combat non-recurring congestion associated with incidents, construction, or special events.

In December 2003, the Association of Metropolitan Planning Organizations (AMPO), in conjunction with the National Coalition on Advancing Transportation Operations, conducted a survey to assess how metropolitan planning organizations (MPO's) incorporated operations and ITS projects in their planning process (*8*). Some of the major findings of this survey are summarized below.

- 66% of the forty-four respondents indicated that they incorporate operations and management projects into their long-range transportation planning (LRTP) process.
- 80% of the respondents indicated that they were <u>not</u> able to adequately model or quantify the benefits of these types of projects.
- 77% of the respondents indicated that 10% or less of the total LRTP investment were operations-oriented projects. Only three respondents indicated that operations-oriented projects represent more than 20% of the projects identified in the LRTP.

- Few respondents (only 14%) provided ongoing support for operations-oriented projects. A few of the most common reasons cited for not providing this support include the following (in order of most frequent to less frequent):

  - Local operating agencies did not bring forward these types of projects for funding through the LRTP.
  - There is not an explicit federal requirement to include operations-oriented projects in the LRTP.
  - There is no identified funding source for operations-oriented projects.
  - Congestion and travel time reliability is not a big issue or concern in the region.
  - Local operating agencies did not bring forward these types of projects for funding through the LRTP.
  - Inability to model or quantify benefits of operations-oriented projects.
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- Conversely, over 63% of the respondents indicated that operations-oriented projects were included in their transportation improvement plan (TIP). Nearly all of the respondents (86%) indicated that operation-oriented projects represented 10% or less of the total TIP funding. The most frequently cited (in order of most to least) types of operations projects included in the TIP are as follows:

  - Traffic signal system improvements.
  - Traveler information systems (511, dynamic message signs, highway advisory radio, etc.).
  - Incident management program elements.
  - Construction of a traffic management center (TMC).
  - Operations of a TMC.
  - Elements of a traffic/weather monitoring system.
  - Freeway service patrols.

  All of these types of projects tend to have a regional focus to them.

- The most frequent reasons cited for <u>not</u> including more operations-oriented projects in the TIP included the following:

  - Proposals were not brought forward by operating agencies.
  - Congestion/travel time reliability is not a big issue in the region.
  - The inability to model/quantify benefits derived for operations-type projects.

- While most agencies are funding capital elements of their operations programs (such as TMCs) with state transportation planning funds, ongoing operations are primarily funded through normal operating budgets.
- The most common ways agencies cited for increasing the likelihood of including operations-oriented projects in the LRTP and TIP include the following:

  - Federal guidance on best practices in incorporating operations projects into regional plans and programs.
  - Improved technical tools (models, B/C analyses, etc.) that compute the effects of non-recurring congestion on operations.
  - Training MPO policy-makers about operations and management.
  - Federal requirements to incorporate reporting on system performance measures for plans and programs.
  - Training of operating agency managers about the role of the MPO, the LRTP, and the TIP in securing funding for operations projects.

Issues Identified in Literature

The literature suggests that there are two types of operation-oriented projects commonly included in TIPs and LRTPs. Some operations-oriented projects are really capital projects designed to support operations. These are projects that are intended to install infrastructure that allow agencies to operate the system better. Examples of these types of projects include the following:

- The construction of a traffic operations center.
- The installation of traffic and weather monitoring systems.
- The installation of communications and control hardware for transit signal priority.
- The installation of communications and control hardware for ramp metering.
- The installation of automatic vehicle identification systems on transit vehicles.

Other types of operations-oriented projects are those that involve performing a service or operating a program of services. Examples of these types of projects include traveler information systems (such as 511), incident management systems, courtesy patrols, etc. Instead of hardware, these projects fund personnel, and supplies to actually perform the tasks or a service, or to upgrade and / or maintain equipment and facilities. The focus of these improvements is more on customer satisfaction and customer service or improving agency efficiency than on installing physical devices or infrastructure.

Another issue identified in the literature as being problematic is the difference in the life-cycles of operations-oriented projects and capacity enhancement projects. Traditionally, the life-cycle used to plan and evaluate capacity enhancement projects is 20 to 25 years – i.e., improvements are "sized" to address problems that will exist 20 to 25 years into the future. The life-cycle of most of the improvements associated with operations-oriented projects is 3 to 5 years. This difference in timeframes creates several issues:

- Because of the differences in the life-cycles, it is difficult to do an "apple-to-apple" comparison of the benefits of proposed improvements.
- Because of the differences in the life-cycles of the improvements, an agency may be required to have multiple operations-oriented projects over the same time frame as one capacity enhancement project. This makes it difficult to generate political support because policy-makers continue to see similar requests for similar projects (e.g., "We just had a program to upgrade signal timing last year, why do we need to do it again?).
- Many operations-oriented projects involve the use of advance technologies which is constantly evolving.

Many operations-oriented projects involve partnerships with agencies and groups (such as emergency services, or information providers, etc.) that, historically, have not received funds from traditional transportation sources, or have been involved in the planning of transportation improvements. Some operating agencies may be hesitant to seek funding for some operations-oriented projects that support other agencies (such as fire, police, EMS, etc.) because they view it as an impingement on their traditional funding sources.

Furthermore, institutional fragmentation within many metropolitan regions can create problems in identifying and evaluating projects. Most metropolitan areas consist of numerous municipal governments, each with their own emergency and support services; one or more transit authority; one or more tolling or regional mobility authority; and occasionally multiple state organizations (and even organizations from multiple states). Each of these organizations has their own legal authority, mandates, and decision-making structure. Some agencies may be unwilling to commit resources to programs and activities that are not solely contained within their jurisdictions.

Historically, projects with the lowest benefit/costs ratio were selected for construction. Because the planning process was originally tasked with identifying "projects" which state DOTs could build, a project-oriented culture was developed that still exists today. Projects were "prioritized" and "selected" for construction based on benefits and costs. Today, we are still trying to use this process to "evaluate" and "compare" operations-oriented improvements to capacity enhancement projects. Most operations-oriented improvements are not isolated type projects with definite start and end dates, but instead are a series of continuous efforts that might occur throughout an entire region over an extended period of time.

PROCEDURES FOR EVALUATING AND SELECTING TIP PROJECTS

We also examined the processes that several agencies and MPO use to select and evaluate potential projects in the development of their respective TIPs. Using the internet, we reviewed the current TIPs of approximately 20 MPOs. Below is a summary of the findings of this review.

Many of the locations that we reviewed did not have a rigorous evaluation process for ranking and selection projects (*9, 10, 11, 12*). In many locations, projects were identified and selected through a consensus process where a committee examined all the project requests and through mutual agreement determined which projects should be included in the TIP and their priority. This practice was more common place in smaller jurisdictions, but was also used in several large metropolitan areas. In many of these locations, operational projects were funded from the same pool of funds as traditional capacity and transit type projects.

Other locations, however, employ a more rigorous process for selecting projects. For example, the Atlanta Regional Commission (ARC), the MPO for the Atlanta, Georgia area, uses a needs-based assessment to select projects for inclusion in the TIP (*14*). After receiving its allocation of funds from FHWA and the Georgia Department of Transportation (GDOT), ARC divides the funds into three broad and overlapping categories: Roadway, Transit, and Bike/Pedestrians. Operations/ITS projects are included in the Roadway category along with improvements focusing on capacity and freight movement. A portion of the allocation is also set aside to fund programs that benefit the region as a whole. The funding levels allocated in each of these categories are based on the priorities specified in the regional transportation plan.

To identify potential projects in each category, the ARC solicits project ideas from the transportation providers and users in the area. ARC performs an initial scoring of all projects using the criteria listed below.

- Accommodation of multiple modes – these are projects that can demonstrate safety, mobility, accessibility benefits to multiple user groups, including motorists, pedestrian, and bicyclist.
- Connectivity with multiple jurisdictions, priority areas or facilities – these are projects that improve connectivity between two or more jurisdictions, priority investment areas, other key community facilities (such as schools, libraries, hospitals, parks and shopping centers), regional intermodal and multimodal facilities (such as transit centers, intermodal terminals, major freight generators and airports), and existing regionally significant transportation facilities (such as expressways, Metropolitan Atlanta Rapid Transit Authority (MARTA) rail corridors, and multiuse paths)
- Compatibility with current plans – these are projects that are in adopted plans such as the regional transportation plan, regional development plan, regional bicycle and pedestrian plan, and the ITS regional architecture plan.
- Community support – these are projects that have already been thoroughly discussed with the affected community and major issues have been resolved.
- Cost effectiveness – these are projects that are likely to result in the greatest benefits (mobility, safety, accessibility, air quality, congestion, etc.) for all users at a reasonable cost.

- Local financial commitment – these are projects that have local match amounts in excess of the required minimum 20% contribution.

Additional points are awarded on a discretionary basis to consider regional equity, Americans with Disability Act (ADA) requirements, and environmental justice impacts.

After an initial screening, potential projects are divided into the three funding categories. ARC then uses project-specific criteria to rank the projects within each funding category. Points are assigned to each project to reflect how well it conformed to established criteria. The criteria used to rank roadway projects are as follows:

- Emphasis on Regional Corridors – projects located along corridors that have been defined as most important for regional mobility receive higher points.
- Safety – projects designed to address locations with high accident rates, high number of severe accidents involving injuries and fatalities, conflict resolution, unsafe or needed shoulders or medians, or emergency vehicle accessibility receive higher points
- System Operations – projects that are part of ITS and management and operations such as signal coordination projects and programs, queue and delay reduction projects and programs, communication and surveillance infrastructure improvements, system maintenance programs, and projects to improve ITS/M&O system continuity receive higher points
- Context Sensitive Design – projects that include strategies to impact surrounding land uses and non-motorized accessibility through land use and zoning compatibility; aesthetics and quality of experience; community character; access management; and safety to all users, including bicyclists, pedestrians, and transit riders receive higher points
- Gaps and Bottlenecks – projects that address existing gaps and bottlenecks through reductions in queues, improvements to safety (in terms to accident reduction potential), and flow improvements.

Additional points are awarded on the basis of how well a project meets a variety of factors including multimodal mobility and accessibility, regional equity, history of project implementation of sponsor, support of comprehensive transportation and land use plans, and environmental justice.

In Atlanta, a strict benefit/cost analysis of projects is not performed in the selection. Instead, project sponsors are expected to clearly demonstrate that projects or programs will be used by a sufficiently large and diverse population group or at a frequency that is reasonable with respect to the total amount of federal funds requested. ITS/operations projects receive a higher weighting than bottleneck/capacity reduction projects.

Although in Atlanta ITS and operations projects compete directly with capacity-enhancement and other types of projects for funds, many other locations provide a direct allocation of funds in which ITS and operations projects compete exclusively. In the Denver area, for example, the Denver Regional Council of Governments (DRCOG) provides a direct allocation of funds for congestion management activities. These funds are used to support programs such as the Regional Traffic Signal System Improvement Program, RideArrangers Program, Regional Transportation Demand Management Program, and the Regional Intelligent Transportation System Program. Similarly, another allocation is provided to support air quality improvements such as the Conformity Finding Mitigation Program, and other air quality projects. Of the total allotment of funds to the Denver region, congestion management activities and air quality improvements receive 19% and 12% of the DRCOG program funds, respectively. This is compared to a 26% allocation for capacity improvements (*15*).

DRCOG also has a separate funding category for roadway operational improvements (which receives 13% of the funds allotted to the DRCOG). Projects in this category are intended to address *current* operational problems and needs. Listed below are the criteria that DRCOG uses to evaluate projects:

- Congestion – points are awarded based on the *current* degree of congestion (V/C ratio) on the existing roadway.
- RTP Emphasis Corridor – points are awarded based on *emphasized* freeways or major regional arterial specified in the regional transportation plan.
- Safety – points are awarded based on *current* weighted crash rate, as compared to the statewide average, and on its estimated crash reduction.
- Usage – points are awarded based on *current* average weekday daily traffic per lane
- Cost-effectiveness – points are awarded based on the cost per *current* vehicle hour of travel reduced during the peak hour.
- Transportation System Management – points are awarded for projects adding features such as median, turn lanes, access point control/consolidation, signal interconnection, and ITS infrastructure.
- Multi-modal connectivity – points are awarded for inclusion of inter-model aspects such as bicycle lanes; new or improved inter-modal connections / transit access (bus shelters, bike racks, etc); and transit signal priority, bicycle signal activation, or transit operational improvements.
- Overmatch -- points are awarded based on providing *above* the minimum 20% local funding match.
- Metro Vision Implementation – points are awarded for sponsor actions implementing Metro Vision (the long-range regional plan for the Denver area).
- PM10 conformity – points are awarded if either the sponsor or project location's jurisdiction has met its PM10 conformity commitment.

While locations such as Denver rank projects based on *current* needs, other locations try to assess projects based on the amount of potential benefits that can be derived from implementing a project. For example, in Houston, Texas, half of the score used to rank projects comes from a benefit / cost analyses of user travel times (*16*). Travel times, or vehicle hours of travel, are calculated on a link-by-link basis and totaled over the length of the project. Travel time savings are calculated as the difference between the travel times on the facility with and without the improvement, using modeled near-term and intermediate (i.e., 10-years) traffic volumes on the existing plus committed roadway network. Travel time savings are accumulated over a 10-year period and adjusted to the net present value. The cost effectiveness, or the benefit/cost index, is then calculated as the product of the ratio of the annual average of the net present value to the annualized cost of the project and an indexing factor.

The other half of the score is determined by planning factors designed to assess the project's impact on congestion, mobility, safety, and regional significance. Different criteria are used depending upon the category of the improvement. Houston Galveston Area Council (HGAC) has four types of improvement categories: roadway improvement, traffic operations and management, bicycle and pedestrian, and transit. The following factors are used to assess projects classified as traffic operations and management:

- Institutional Coordination – assesses a project's ability to improve coordination with other entities and stakeholders.
- System Redundancy – assesses how a project backups or provides an alternative to existing services and systems in the case of system failure.
- Performance Measures – assesses a project's ability to reduce traffic congestion, maintain/preserve existing system, improve travel options, improve air quality compliance, enhance system integration and effectiveness, and improve safety planning.
- Maintenance Costs / Staff Resources – assesses the recurring cost, staff resources and training needs of a project and assesses the degree of financial commitment from sponsor.

- Homeland Security – assesses infrastructure security, interagency coordination, leveraging transportation and safety funding.
- System Migration and Expandability – assesses use/enhancement of existing communications and data networks
- Integration and Information Sharing – examines market package compliance and level of integration.

To be eligible to use Congestion Mitigation and Air Quality (CMAQ) funds, a project must demonstrate air quality benefits due to reductions in mobile source emissions. The emission reductions are calculated based upon travel time savings, reductions in idling time, and / or reductions in vehicle miles of travel (VMT). All air quality emissions are calculated using Texas mobile source emissions reduction strategies (MoSERS) and emissions factors from MOBILE6.

A similar process is used in the Maricopa County/Phoenix, Arizona area (*17*). In this region, the Maricopa Association of Governments (MAG) has developed a Congestion Management System (CMS) rating process for evaluating the impacts of projects on traffic congestion. The rating system evaluates projects based on several factors including volume to capacity ratios (V/C), cost effectiveness, mobility zone strategies, and modal enhancements. Each project is initially awarded 50 base points. Based on the input data from the applicant, additional points can be computed and added to the project's base points. Congestion factors, performance cost factors, mobility factors, and multi-modal factors are then used to "standardize" the scores (i.e., produce "z-scores"). The "standardization" process converts all raw scores into standard deviation rankings that eliminate the need to compare or convert different units of measurement (i.e., cost per passenger mile compared to volume-to-capacity ratios). Using the z-scores multiplied by various weighting factors, the base points plus the standardized scores are normalized to produce scores between 1 and 100. Higher scoring projects are better than lower scoring projects at reducing congestion.

To rank ITS projects, the MAG has established an ITS Committee which was specifically formed to address the development and implementation of an ITS planning program for the region. This committee is responsible for prioritizing ITS projects through the development of an ITS Project Rating System. The system divides all ITS projects into two categories: non-Transit and Transit. Each project is then scored based upon the following:

- Deployment Priority
- Congestion
- Costs, and
- Local Match

At a special meeting of the ITS committee, each project is presented and the committee uses the following information to determine the priority of the projects:

- Scores for the ITS Rating System;
- Scores generated by the CMS;
- MAG emissions estimate.

A final ITS project prioritization is based on the subjective project ranking generated by committee members.

One location that uses rather unique criteria for evaluating potential projects is the Seattle / Puget Sound area (*18*). In the Seattle / Puget Sound area, the long-ranging planning focuses on promoting growth and development of the following:

- Urban centers
- Manufacturing / industrial centers, and
- Connecting corridors

TIP projects are evaluated using criteria corresponding with each specific center. For those projects identified as affecting urban centers, projects are assessed to determine their effect on the following criteria:

- The urban center environment.
- The impact the project has on the urban center.
- The circulation within the center.

To assess the effects of the project on the urban center environment, projects are rated (using a "High/Medium/Low" scale) on how they support the following:

- The potential for increased housing/employment densities in the center.
- The development/redevelopment plans and activities in the center.
- The objectives and aims of existing policies for the center.

A project would receive a high rating if it clearly supports the potential for a large amount of increased activity, implements specific projects identified in an adopted policy or plan, and enhances an urban center's sense of place.

In evaluating a project's potential to impact an urban center, the same type of scale is used to rate how the project remedies current or anticipated problems (e.g., congestion, inadequate transit service/facilities, etc.) and who benefits from the project (i.e. does it serve a wide variety of users or provide environmental justice activities). A "High" rate project would be one that remedies a long-identified existing or anticipated problem and would benefit a large number and variety of users.

Urban center type projects are also evaluated on their impact on circulation within the center. Specifically, projects are rated on how they affect the following:

- Improve safe and convenient access to major destinations within the center.
- Improve circulation within the center in terms of walkability, public transit access, public transit speed and reliability, safety and security, bicycle mobility, bicycle facilities, streetscape improvements, traffic calming, and/or others.
- Provide users (e.g. employees, residents, customers) with a range of travel modes or provides a "missing" mode.
- Complete physical gaps or provides an essential link in the transportation network
- Employ innovative parking management tools to be compatible with a pedestrian-oriented environment.

A "High" rated project would be one that significantly improves access to, or circulation throughout, the urban center; benefits a variety of transportation modes; and employs innovative design or program management.

Projects identified in the *Manufacturing/Industrial Centers* category are intended to focus on improving freight management and access to industrial centers in the region. Using a "High / Medium/ Low" ranking scale, projects in this category are evaluated against the following criteria:

- The project's ability to provide opportunities for freight movement.
- The project's ability to provide an essential link or remove a barrier in the movement of freight and goods by completing a physical gap in the transportation system.

- The project's ability to improve safety and reduce modal conflicts to help achieve a "seamless" system.
- The project's ability to improve access for one or more modes to major employment sites or access to residential areas outside the center.
- The project's ability to promote Commuter Trip Reduction (CTR) opportunities.
- The project's ability to benefit a wide range of user groups (e.g., employees, customers, modal carriers, and those identified in the President's Order for Environmental Justice).

A "High" ranking project would be one that exhibits the following characteristics:

- Streamlined the efficient movement of freights and goods through a significant reduction in travel time, along with increased safety (such as providing an essential link or removing a barrier.
- Improved the mode share of travel by providing alternatives to driving alone, such as transit or ridesharing.
- Benefited a large number and variety of users, including those identified in the President's Order for Environmental Justice.
- Contributed to further development of the center.

Projects in the *Connecting Corridors* category are rated on their ability to provide the following:

- Benefits to the centers,
- System continuity, and
- Sustainability.

In assessing the benefits to centers, projects are evaluated on their ability to benefit or support the development of one or more urban and/or manufacturing/industrial center, provide users traveling to the center with a range of travel modes or provide a missing mode, and impact a wide range of users. Project ranking "High" in this area would demonstrate the following characteristics:

- Provides clear benefits to a center by expanding the person carrying capacity of routes leading toward the center.
- Demonstrates that it helps a center meet its development goals (and can reference those goals).
- Improves access to the center for multiple modes, including non-motorized and transit.
- Serves multiple user groups, including those without full-time access to cars, and those identified in the President's Order for Environmental Justice.
- Is adjacent to dense, mixed-use areas that are likely to generate significant use of the project.

For the system continuity measures, projects are rated on their ability to provide a "logical segment" that links to a center, to fill a missing link or remove barriers to a center, and to relieve pressure or remove a bottleneck in the system and the positive impacts this would have on overall system performance. "High" rated projects in the measure would demonstrate the following characteristics:

- Improves a corridor in logical segments, preventing the creation of missing links or gaps, thereby improving access to a center.
- Addresses critical gaps or barriers in the development of a corridor, creating greater efficiency or reliability in accessing a center.
- Removes a bottleneck that improves the overall system performance and creates improved access to a center.

Projects in the category are also rated on their sustainability. To receive a "High" rating in this evaluation measure, projects would need to show that they provide a long-term solution for meeting projected travel demand to a center. An ITS improvement that provides information to drivers along congested corridors, including transit priority technology, or providing queue-jumps for HOVs are cited as an example of a project receiving a "High" ranking.

In addition to the evaluation criteria depending upon the specific type of center to be supported by a project, all projects are also rated on the following:

- Their readiness and financial plan, and
- Their air quality impacts.

The first measure is intended to assess how quickly the project can be ready to go to implementation and if the matching requirements have been fulfilled. The second measure is intended to assess how the project provides emissions reduction through eliminating vehicle trips, inducing a mode shift away for single occupant vehicles; reducing vehicle mile traveled (VMT); improve traffic flow; changing fuels, equipment, fuel systems, and/or vehicle; and other emission reduction opportunities. These measures are used in evaluating both STP-funded and CMAQ-funded projects. For CMAQ-funded project, however, the air quality factors are weighted more heavily.

The Capital District Transportation Committee (CDTC), the MPO for the Albany, New York region, uses a very extensive process for evaluating and selecting projects to be included in the TIP (*19*). As with many other locales, projects are first screened to determine which of the following budget categories would be appropriate for funding the improvement:

- Bridge
- Pavement
- Transit support
- Safety
- Community compatibility / economic development
- Congestion relief, and
- Bicycle and pedestrian

Projects within each category are then evaluated for merit using a benefit to cost analyses. CDTC uses the following five measures to generate estimates of benefits:

- Safety
- Travel time savings
- Energy / user savings
- Life cycle cost savings
- "Other" benefits

Safety benefits are measured in terms of the dollar value of the projected reduction in accidents per year. These benefits are computed as the product of the average annual accidents, the expected percent reduction in accidents resulting from the improvements, and a monetary equivalence factor taken from standardized tables developed by the New York State Department of Transportation (NYSDOT).

The monetary benefits of the mobility improvements are estimated by calculating user operating cost savings and the monetary value of travel time savings that would result from implementing the improvement. CDTC uses their long-range travel demand model to forecast traffic demands both with and without the improvement. User operating costs and travel time costs are calculated as the difference in the costs resulting from these two assignments. The user operating costs are estimated as the result from the increased capacity and improved operation that the project is expected to provide. Travel time savings are measured in terms of the annual dollar value of the projected time saved by implementing the project. It is estimated as the product of the change in total delay per year (based on delay per vehicle per day, the daily traffic volume, and the number of days in a year when the condition exits), and a monetary equivalency factor. The monetary equivalency factor was derived from NYSDOT Highway User Cost Accounting Microcomputer Package.

Energy and User Cost Savings are computed differently for pavement improvements and for mobility projects. With pavement projects, energy costs are estimated as the product of the daily change in operating fuel consumption, the daily volume, the number of weekdays in a year, and a monetary equivalence factor. For projects intended to improve mobility, energy and user cost savings are estimated as the product of the average highway vehicle operating costs and the estimated vehicle miles traveled annually. The average highway vehicle operating costs is determined by comparing the estimated operating speed with and without the improvement to the posted speed. It is assumed that if the operating speed is less than the posted speed limit, congestion will occur.

Life cycle cost savings are applied primarily to infrastructure improvements and are calculated using the CDTC long-range travel demand model to estimate the system disbenefits of letting a bridge or pavement section deteriorate to the point of abandonment. For mobility type projects, the value of a facility is estimated by comparing the regional travel time savings and user costs saving with and without the improvement in place.

The CDTC also captures the monetary benefits (or disbenefits) of other factors that are not directly contained in the other calculations. These “other” benefits include changes to the system-level measures of transportation system costs such as the following:

- Private vehicle ownership
- Parking provision and use – work trip
- Parking provision and use – other commercial
- Parking provision and use – residential
- Transportation related fire/police/justice expense
- Regional air pollution
- Global air pollution (climate change)
- Vibration damage
- Water quality damage
- Waste disposal
- Energy use impacts on costs of national security and impact on international trade

The CTC recognizes that the accrual of these benefits occur over the long-term and at system-level (as opposed to project-level benefits), and therefore, apply this factor only to projects that are significant enough to affect system-level travel (e.g., projects that generally affect the number of vehicle trips or the aggregate level of system miles of travel in the Capital District).

Observations

The following is a summary of the observations based on the review of the TIP documents:

- Many locations use a consensus process for selecting and prioritizing projects for inclusion in the TIP. Many locations do not use a formal evaluation process (or at least did not report using a formal evaluation process) in developing their TIPs.
- In those locations where a formal evaluation process is used, some locations use a subjective evaluation process to identify the potential benefits of a project. At these locations, the MPO or an evaluation committee rates or assigns points to how, in their opinion, the project will impact some performance measures (i.e., safety, traffic congestion, etc.).

- Most locations use multiple performance measures and criteria to assess and rank projects. The specific measures that are used in these evaluations vary greatly from location to location. Therefore, analysis tools need to support the use of multiple performance measures (such as traffic flow improvements, accident reductions, etc.) Analysis tools should allow users to select the most appropriate performance measures for their location.
- Subjective measures, such as environmental justice, the desire to promote growth or development in a particular corridor/sub-region, system redundancy, etc. are often used in combination with objective measures in ranking projects.
- Many locations are beginning to make specific allocations of funds to support operational programs. This allows agencies to directly compare operational projects with other operational projects.
- Many locations are installing infrastructure to support operations as part of the capacity enhancement projects. It is here that improvements also need to be accounted for as part of the evaluation and selection process.

WORKSHOP

On Thursday, January 13, 2005, the Texas Transportation Institute (TTI) in conjunction with the Federal Highway Administration (FHWA) conducted a workshop to determine the user needs for integrating and evaluating ITS and operations projects into the planning process. The purpose of the workshop was to solicit input from representatives from metropolitan planning organizations (MPOs) and state departments of transportation (DOTs) about the process and the tools they use for incorporating ITS and operations projects in the planning process and what needs and tools FHWA might provide to assist agencies in making ITS and operations more "competitive" in the planning process.

Participants

The workshop included a small group of representatives from six MPOs and two state DOTs as well as representatives from three producers of products commonly used to evaluate ITS and operations-oriented projects by the planning and operations community. Each participant gave their perspective on how operations-oriented and ITS projects were included in the planning process at their local levels. A list of the participants is shown in Appendix A.

Structure of Workshop

The structure we used in the workshop is shown in Appendix B. The day was divided into three sessions – each session included presentations from three participants followed by an open-discussion. In the morning session, the state DOTs and MPOs representatives were asked to describe the process and procedures they currently use for including operations-oriented and ITS projects in transportation improvement plans (TIPs). At the conclusion of each session, an open discussion was held to allow all the participants to ask questions and discuss issues brought out in the presentation.

In the afternoon session, the three product-producers made a presentation on how their software system could be used, potentially, to evaluate operational projects. Session 4 consisted of an open discussion to brainstorm about user needs in assessment tools. Copies of each of the presentations are contained in Appendix C.

Session 1

Phil DeCabooter, Wisconsin Department of Transportation (WisDOT)
For the first time, Wisconsin DOT (WisDOT) has undertaken the effort to integrate operations into their long-range planning process. This was done because WisDOT recognizes that future program needs must be expanded to include operations.

WisDOT's planning efforts are being done at two levels. Investment management is responsible for estimating costs and impacts of ITS and operations and maintenance projects. WisDOT is also developing an ITS strategic program plan, part of a statewide traffic operations plan that focuses on the development and deployment of ITS infrastructure. In the plan, ITS deployments are addressed at four levels:

- A strategic level
- A project/study specific level
- A programmatic level
- A coordination level

The strategic level is intended for senior leadership and provides high level guidance for the implementation of ITS throughout the state. At the project/study level, the plan outlines a department-wide concept of operations for ITS, consolidates existing local architectures statewide, and develops staff needs and consolidates existing deployment plans. At the programmatic level, the plan calls for WisDOT to maintain and update the ITS concept of operations, allocate resources to ITS deployment, establish a coordinated program for operating and maintaining ITS, and evaluate and report ITS program results. The plan also discusses the level of coordination required to implement ITS in Wisconsin.

Natalie Bettger – North Central Texas Council of Governments (NCTCOG), Dallas-Fort Worth Area, Texas
NCTOG uses two methods to identify operations-oriented and ITS projects for inclusion in the TIP: a "Call for Projects" process and a "Strategic Selection" process. In the "Call for Projects" process, local governments and transportation agencies submit project ideas for competitive ranking. Projects are evaluated and ranked based on the following criteria:

- The cost-effectiveness to reduce travel time,
- Cost per pound of emissions reduced,
- Local cost participation (about 20 percent), and
- The degree to which the project supports inter-modal, multi-modal, and social mobility goals for the region.

ITS projects also receive additional credit for the following:

- Targeting incident detection and response technology and mobility assistance programs to congested corridors,
- Filling gaps in the existing ITS communication infrastructure,
- Enhancing or providing communication and information exchange,
- Targeting investment to facilities undergoing reconstruction, and/or
- Creating or enhancing public/private partnerships that will aid the identification and mitigation of traffic congestion.

In the "Strategic Selection" process, agencies are asked to identify (in ranked-order) their high-priority projects. Projects are selected to achieve a balance between agencies' desires and available resources. NCTCOG also tries to balance of projects through the entire Dallas-Ft. Worth area. Significantly more operations-oriented and ITS projects are included in the TIP when a committee composed of representatives from the various operating agencies are included in ranking and selecting projects.

Some of the major challenges that NCTCOG faces include the following:

- *Lack of data that show the system-wide impacts of events.* – In particular, what impact non-recurring congestion has on the entire transportation system (and not just the corridor or facility where the incident occurs). System effects need to be known by facility type, number of lanes closed, incident severity, etc.
- *Lack of good "before and after" studies that quantify the impacts of ITS projects.* – It is not that before and after studies do not exist, but every project seem to be implemented differently and in different situation, making it difficult to determine how the benefits might be applicable to your situation. There is a need not only to quantify the benefits of the improvement, but also to capture more information about the circumstances to which the benefits are applicable.
- *Difficult to anticipate driver behavior* – To make assessments of the effectiveness of certain improvements, agencies are often required to anticipate or infer how driver will respond to or react to certain improvements. In many cases, there is not good evidence to support how drivers will interpret and react to certain operations-oriented and ITS projects. There is a need to examine in more detail how ITS and operations projects affect driver behavior.
- *Size of the Dallas-Fort Worth area* – Because of the geographic size covered by the NCTCOG, it is difficult for 1) most of the decision-makers to have intimate knowledge of the entire area, and 2) it is difficult for assess the impacts of some improvements over the entire area.

<u>Lisa Klein – Metropolitan Transportation Commission, San Francisco-Oakland Area, California</u>
Most of the operations-oriented and ITS projects included in the Metropolitan Transit Commission's (MTC) plan can be grouped into three categories:

- Established regional customer service programs.
- "New" regional customers service programs.
- Locally/corridor oriented projects.

The established regional programs include those that have been operating for years (e.g. 511, smart card, call boxes, service patrols, etc). These programs are generally accepted by the MTC board and public, and continue to receive funding (at least at their current levels), even though it is difficult to obtain good, quantitative measures of benefits for many of the projects.

The MTC also supports new regional programs. These are efforts that emerge with a regional focus or where established programs evolve into broader strategic efforts. Programs in this area include efforts to establish an integrated communications system for incident management and enhanced freeway operations, and demonstration projects. Because these efforts are generally new, regional in nature, and often the first of their kind, limited data and analysis tools make it difficult to evaluate these projects. Locally and corridor-oriented projects include those projects developed at the city, county, or transit district level or are corridor- or locally-supported implementations of regional plans such as ramp metering or HOV lanes. For many of these projects, simulation tools are used to assess impacts and generate support.

Recently, MTC conducted a project level evaluation of over 900 projects. The projects were evaluated to assess how they met regional goals including operational efficiency, reliability, and improved customer service. MTC relied primarily on the regional travel demand model to complete the evaluation. This approach imposes limitations for all projects, but especially for operations projects. However, the large number of projects would makes it difficult to used specialized tools that might be more conducive to evaluating operations projects. MTC may try to limit the number of projects to evaluate or may try to focus on larger projects and projects of particular interest. Tools are needed whereby operational projects can be grouped for analysis at a regional level as opposed to corridor level.

The number and scope of funded operations projects reflects a balancing act between needs and available resources. Operations projects are higher priority in MTC's long range plans. New projects have to compete with maintenance and expansion of established programs. Maintenance of existing programs continues to take a larger portion of available funds. Tools are needed to help assess how projects can be scaled back to fit within available resources. It is also difficult to predict operations costs and needs more than 10 years into the future.

The Metropolitan Transportation Commission (MTC) is just completing a revision to their long-range plan [Transportation 2030 (T-2030)], and operations, as a concept, is more prominent than in past years. The plan provides a framework based on three strategies to meet future mobility needs: maintenance, system efficiency, and strategic expansion. Operations and ITS projects are key elements for of the system efficiency strategy.

The plan includes "calls to action", which are beyond the projects identified in the plan, but are critical for accomplishing the system efficiency goals and objectives of the area.

Open Discussion

Below is a summary of the discussions that occurred during the open discussion after Session #1.

- Operations-oriented and ITS projects do not seem to be as high profile as capacity improvement projects. There is no dedicated funding source for operations projects. How do we fix that?
  - Inform elected officials on benefits of operations projects.
  - Tools need to include evaluation of impacts of projects on air quality conformity.
  - Evaluation tools need to compare and show impacts in relation to capital projects.
  - Tools need to justify and evaluate individual projects and show benefits.
  - Tools also need to show incremental benefits of making multiple improvements.
  - Tools need to be able to evaluate ITS benefits on a corridor level, not just a project level.
  - Tools need to look at tradeoffs between projects for selection.
  - Tools and measures are needed that can capture and quantify customer service type effects.
- There is also a need to be able to quantify benefits at the program level that might be implemented beyond just a project or corridor level. Programs are those improvements that are implemented throughout the entire region – for example, courtesy patrols, 511, etc.
- There is often not very much time to do a complex evaluation or exhaustive analyses of alternatives. A tool or process is needed that could be used in two stages: one to "scan" the alternatives, another to do an in depth quantification of benefits
- Staging of improvements is also an important issue to capture. Tools need to recognize staging, (i.e., in order to do "x", you need to do "y" first). Also, in areas where you are doing both capacity and operations improvement in project, tools need to be able to quantify effects of both.

Session 2

Eric Hill – MetroPlan Orlando

MetroPlan Orlando is the regional planning organization for Seminole, Orange and Osceola counties in the greater Orlando, Florida area.

The history of ITS deployments in the Orlando Metro area has been disjointed, primarily funded by local agencies through local projects. Major deployments of ITS by the state department of transportation have been funded primarily through federal earmarks. The combined level of state and local funds for congestion management projects (which involves ITS) in the late 1990s was approximately $2 million per year.

MetroPlan has used the ITS Deployment Analysis System (IDAS) to incorporate ITS and operations projects in the 2025 long range transportation plan. These projects include the following:

- Improved signal coordination
- Transit vehicle signal priority
- Ramp metering
- Automated transit scheduling
- Incident detection and response
- Monitoring of highway/rail grade crossings
- Highway advisory radio
- Dynamic message signs
- Traveler information systems, and
- Traffic surveillance.

IDAS was used to assess the benefits and cost of these improvements in five deployment scenarios:

- Complete deployment of existing ITS deployments currently planned
- 25% deployment, to include complete instrumentation of the major roadway network
- 50% deployment, to include expanded auto and bus traveler information
- 100% deployment to include improved traffic incident management and dynamic routing capabilities, and
- 100% deployment integrated with rail operations.

Some of the major issues facing MetroPlan include the following:

- Project selection criteria – those agencies with the loudest voice have historically had more success in getting their project selected. The process is not always equitable. Developing consensus on the selection criteria should make the process more equitable.
- Allocation of funds – given that funding is available to address an issue (e.g. signal improvement), how are these monies divided between all agencies that operate signals (e.g. all three counties, the city, the state, etc.)? Are monies divided on a per signal basis, evenly distributed, or focused on specific corridors?
- Quantitative analysis – It is difficult to evaluate the effects that regional and customer service oriented programs (such as courtesy patrols) have on operations. Current analysis tools support project-type evaluations and do not lend themselves well to doing evaluations of programs.
- Before and after studies – There are not enough detailed before and after studies available to show the complete range of benefits and cost that can be derived from doing ITS and operational improvements.
- Evolution – Systems have a tendency to evolve over time. Goals and objectives of systems change as the system matures. Implementations of improvements/programs lead to innovations in other parts of the system. These evolutions are difficult to capture.

<u>John Ward – Delaware Valley Regional Planning Commission</u>
The Delaware Valley Regional Planning Commission (DVRPC) is the MPO for the nine-county region in the Philadelphia Metropolitan Area. One unique feature concerning this region is that portions of the region exist in two different states: Pennsylvania and New Jersey.

Most of the planning efforts done by the DVRPC are of a regional nature. ITS deployments included in the Transportation Improvement Plan (TIP) are as follows:

- Closed loop traffic signal systems,
- Operations of the regional traffic operations center
- Emergency service patrols

Many ITS deployments are actually components of larger construction projects. The result is a piecemeal roll-out of network instrumentation (i.e. closed circuit television, variable message signs, detectors, etc).

Some key issues discussed include the following:

- DVRPC does not do any technical analysis of projects. Each individual entity is responsible for identifying and selecting projects for inclusion in TIP.
- Most of the infrastructure, especially traffic signals, are locally owned and operated. They are not viewed as a regional resource. There is no master plan for signal systems and the information about what exists and how it operates is incomplete.
- Much of the capital costs associated with ITS deployment are incorporated into construction projects and little thought is given to the long-term operations and maintenance costs of the equipment.
- There is no regional ITS master plan to guide the identification and deployment of individual ITS projects. Likewise, there is no regional evaluation process for assessing the effectiveness of these deployments.

<u>Bill Tansil, Michigan Department of Transportation</u>
One of the current priorities of the Michigan Department of Transportation (MichDOT) is to preserve the system first by:

- Preserving the existing investment in the infrastructure,
- Squeezing the most out of the existing resources,
- Continuing safety and security efforts, and
- Operating the system more efficiently.

ITS is viewed as a mechanism for accomplishing this priority. Some of the major ITS initiatives being considered in Michigan include regional operating organizations, international border safety planning, a probe vehicle initiative, and an infrastructure-auto initiative. Regional Operating Organizations (ROOs) include representatives from state and local transportation and law enforcement agencies as well as private information providers in the southeast Michigan area. Their current efforts are focusing on retiming traffic signals in the region, developing and operating courtesy patrols, and operating the Michigan Intelligent Transportation System Center (MITSC), co-located with the state police.

MichDOT's international border safety initiatives are examining operations and security issues at each of the major border crossings. Issues currently being examined include integrating cameras with other security and operations system and sharing this information with Ontario. MichDOT is also looking to increase operational efficiency at these crossings by implementing pre-clearance systems to support just-in-time deliveries. MichDOT is also exploring systems to track shipments through border crossings and through the state.

MichDOT is exploring the use of a vehicle probe system to develop a real-time traffic information network with the intent to manage congestion via traffic information. This system will also improve asset management by identifying safety concerns and monitor pavement conditions statewide.

The infrastructure-auto initiatives are intended to develop and integrated network of transportation information info-structures whereby information is shared directly between the automobile, the roadway infrastructure, and operations agencies in a seamless integrated fashion.

MDOT hopes to fund these initiatives through the federal monies.

Open Discussion
Much of the discussion following the presentations in Session 2 centered on the funding of operations and ITS projects. Below is a summary of key points from the discussion:

- The current project selection process makes it difficult to make capacity enhancement projects compete with operations and ITS projects on the same level. NCTOOG has attempted to address this by identifying “buckets” of monies in which similar types of projects compete – ITS is one of these “buckets”.
- The life span of operations oriented and ITS projects is relatively short (3-5 years). It is difficult to extrapolate benefits and cost 20 years into the future to make a valid comparison to highway projects.
- Senior management and decision-makers often don’t understand multiple requests for operations funding. Many still have the mindset of construction funding – that is, a one time project with a 20-year lifespan.
- Some agencies are doing post-processing of planning models to assess benefit-cost analysis of projects. Agencies often do not have the time to perform multiple comparisons of alternatives.
- Most agencies do not have data specific for their region to assess benefits; therefore, they must rely on results reported in literature. Site specific data are needed.
- Agencies should not underestimate public opinion when selecting projects. There are often trade-offs associated with the selecting process.
- Maintenance, particularly infrastructure-related, such as snow plowing, pot-hole patching, etc., are viewed as critical to decision makers. They are not likely to shave monies from maintenance to fund operations projects. The monies are most likely to come from capitol construction projects.

Session 3

The intent of Session 3 was to compare and contrast some of the tools available for assessing ITS and operations projects in the planning process. The tools discussed included the following:

- ITS Deployment analysis System (IDAS)
- DynaSmart-P
- VISSIM Micro-simulation model

Krista Jeanotte, Cambridge Systematics
IDAS is a sketch-planning tool designed to estimate the benefits and costs of over 60 types of ITS implementations. It was designed to assist planning agencies in integrating the deployment of ITS into the transportation planning process. It uses the outputs of traditional travel demand models to analyze the cost and benefits of different ITS and operations-oriented improvements, either in isolation or in combination with other improvements. It is capable of estimating the impacts and responses of travelers to different ITS improvements, estimating the life-cycle cost, identifying potential cost-shaving opportunities, and evaluating scheduling of ITS deployments. Its strengths include the following:

- Consistent with current transportation planning models and outputs for comparing alternatives.
- Input data readily available from travel demand model – no data collection required.
- Can be used without extensive knowledge of traffic modeling or simulation.
- Can be used to compare ITS deployments either in isolation or combination at the regional level.
- Default impacts and costs parameters can be changed to reflect local conditions.
- Extensive set of performance measures can be used to assess benefits and costs.

Some of the limitations of IDAS include the following:

- IDAS cannot be used to analyze rural ITS or non-ITS type operational improvements, such as road weather information systems, HOV lanes, toll lanes.
- Some problems have existed in transferring data from some travel demand models doing initial set up.
- Uses a static travel demand assignment process
- The methodology used to analyze traveler information systems may not adequately capture traveler responses.
- Because transit networks are not directly modeled, IDAS has limited transit analysis capabilities.
- IDAS has limited graphical output; there are no animation capabilities.

<u>Hani Mahmassani, University of Maryland</u>
DynaSmart-P is a transportation network planning and evaluation tool that uses mesoscopic simulation principles to model vehicle movements through the network. Its primary function is for strategic long-range planning and traffic operations studies. It can be used to identify operation deficiencies and evaluate the impacts of different operation strategies and control alternatives at a corridor or network-wide level.

One feature that DynaSmart has over other evaluation tools is that it supports dynamic vehicle assignments. It recognizes different vehicle classes in terms of the availability of advance traveler information systems, driver's knowledge of the network, and driver compliance to supplied routing or diversion information. This feature allows for more realistic evaluation of the impacts of traveler information systems on vehicle performance.

Some of the strength of DynaSmart-P includes the following:

- It can model the impact of time-dependent geometric and operational restrictions such as time-dependent lane use restrictions, high Occupancy Vehicle (HOV) lanes and High Occupancy Tolling (HOT) lanes.
- It also has the capability to represent vehicle with predetermines routes, such as transit vehicles.
- It contains the ability to load trip chains with several intervening stops of different duration to more closely represent motorist behaviors.

Some of the weaknesses of DynaSmart-P include the following:

- A new version of the software was just released. There has been little independent verification or use of the software in a non-research environment.
- It does not explicitly compare costs or benefits associated with making an improvement. A post-processor is needed to conduct an economic evaluation of alternatives.

<u>Jim Dale and Martin Fellendorf, PTV America and PTV AG</u>
Jim Dale and Martin Fellendorf with PTV American and PTV AG made a presentation on using microscopic simulation, in general, and VISSIM®, in particular, for evaluating operations and ITS projects.

Microscopic simulation using theoretical car-following and traffic behavior principles to model how individual vehicles interact with one another in the transportation system. By aggregating the effects of all the interactions, transportation modelers can assess the impacts of different geometric and control strategies on the operations of the system. Produced by PTV AG and distributed by PTV America, VISSIM® is an example of a microscopic simulation model.

Because microscopic simulation models model the behavior of individual vehicles, they are particularly well-suited for examining situation where it is important to capture the interaction between vehicles (e.g., merging or weaving behavior at ramps and interchanges). Microscopic simulation models are ideal for evaluating the effects of complex traffic signal and control algorithms.

Microscopic simulation has been used to assess the following:

- The effects of dynamic message signs, lane control signals, variable speed zones on freeways.
- The impacts of incident management and ramp metering strategies of freeway performance.
- The operations of toll plazas, HOT, and HOV lanes
- The effects of adaptive and advanced signal control strategies on arterial street operations.
- The impacts of transit signal priority on traffic signal operations.
- The performance of railroad grade crossing strategies.

Some of the advantages of microscopic simulation (and specifically VISSIM®) are as follows:

- Most microscopic simulation models can simulate multi-modal traffic flows. VISSIM® in particular can simulate not only cars, and trucks, but also buses, heavy rail, trams, LRT, bicyclists and pedestrians.
- Microscopic simulation models allow users to conduct detail analysis of complex traffic situations and control strategies.
- Microscopic simulation models often use 3-D and 4-D animations of the display the results of the simulation. Animation allows users to quickly visual the effects of improvements on traffic performance.

Some of the disadvantages of microscopic simulation include the following:

- Microscopic simulation models often require a large amount of detailed data before even the most basic traffic scenario can be modeled.
- Microscopic simulation models often require calibration in order to produce accurate results that replicate existing conditions. The calibration process can be difficult and time-consuming.
- Because of the large data requirements, microscopic simulation is most often used to analyze isolated location and, with less frequency, corridor- or project-level improvements. With most microscopic simulation, there is a limit on the size of the network that can be model.

Session 4

The final session of the workshop was an open discussion. The purpose of this session was to identify some of the needs and requirements that agencies had in integrating and evaluating ITS and operations-oriented projects in the planning process as well as some potential action that FHWA could take to fulfill these needs. The following tables provide a summary of the identified needs and potential actions.

Summary of User Needs and Potential Actions for Addressing Those Needs Identified in the Workshop.

Category	Description of Need	Potential Actions to Address Needs
Education	• There is a general lack of understanding about the capability and limitations for the different types of evaluation tools.	• Develop a catalog that shows the different capabilities and limitations of the evaluation tools. • Use national teleconference to discuss issues related to conducting evaluations. • Create a clearinghouse where practitioners can post and locate information on use cases, benefits, and experiences with different tools. • Develop of synthesis of practice • Develop an NHI training course that provides a standard methodology for modeling benefits. The target audience for this training should be those that are mid-career and are responsible for performing the evaluations. • Provide training opportunities at AASHTO, AMPO, ITS America, ITE annual meetings. • Provide cross-training opportunities for operations personnel on developing effective projects for inclusion in TIP
	• There is a need to inform elected officials and decision-makers on the benefits and importance of operations-oriented and ITS projects.	• Examine alternative measure for reporting and assessing the effectiveness of the performance of operational improvements. • Create briefing materials that show the importance and benefits of operations
Data Requirements	• There is a lack of quality data that show the system-wide impacts of events	• Obtain more accurate benefits and costs information about system-wide impacts of ITS and operations-oriented projects. • Identify boundaries in determining benefits – what are the local impacts vs. the system impacts. • Provide local data wherever possible but also provide data from locations of similar size, network topology, geography, and traffic characteristics. • Develop a guidance document that shows users how to find or adjust known benefits and cost information to more closely meet local conditions. • Develop a methodology for capturing impacts of system-wide programs as opposed to individual projects. • Provide full instrumentation of entire network to allow better monitoring and comprehensive data bases
	• There is a need to develop a common language and share data between	• Create standard for exchanging data between operations and planning • Create a catalog of data requirements commonly used by operations and

Category	Description of Need	Potential Actions to Address Needs
	operations and planning personnel.	planning evaluations • Create common definitions and meaning for the data used by operations and planning
	• There is a lack of good "before and after" studies that quantify the impacts of ITS projects	• Provide local data wherever possible but also provide data from locations of similar size, network topology, geography, and traffic characteristics. • Develop a standard reporting mechanism that users can use to provide benefit and cost information. • Create a clearinghouse where practitioners can post and locate information on use cases, benefits, and experiences with different tools. • Expand upon the available number and types of use cases.
	• Many agencies are using the tools only to quantify the economic benefits of projects. There is a need to have examine how operational projects can be sequenced over time to generate long-range improvements	• Develop a standard methodology for conducting evaluations of ITS and operations-oriented projects. Don't be constrained by model type, but focus on methodology. • Develop an analysis tool that performs a tradeoff analysis of alternatives and identifies sequence of improvement that maximizes incremental benefits (i.e. develops a program and staging of improvements for long-term). • Develop an analysis tool that examines the effects of sequencing operations improvements in conjunction with capital improvements
Analysis Tools / Techniques	• Tool developers need to be cognizant of time constraints and data accessibility requirement of users. Many agencies do not have the time to full evaluation of many different alternatives	• Develop mechanism whereby archived operations data can be fed directly into evaluation tools. • Develop a user-interface that allows user to select different alternatives for inclusion in alternatives analysis. • Develop analytical tool that allows quick screening of alternatives, and then allow users to perform more detailed analysis of alternatives (maybe an integration of IDAS and
	• It is difficult to anticipate driver behavior in response to improvements.	• Conduct research that examines how driver behavior changes in response to different operational strategies (especially traveler information systems) • Incorporate driver behavior effects into analysis tools
	• Analysis tools do not consider impact of projects on long-term operational resources	• Develop methodology / guidance on how different operational improvements impact local agency resources – in terms of full-time equivalent employees, staff capabilities, etc.
	• There is a need to quantify impacts of operations project on air quality conformance and customer satisfaction/ customer service	• Incorporate methods for quantifying air quality impacts • Change "rules" to allow agencies to obtain air quality credits for performing operational improvements • Incorporate methods for assess impacts of operations-oriented and ITS

Category	Description of Need	Potential Actions to Address Needs
		projects on customer satisfaction or ability of agency to provide customer service.
Performance Measures	• There is a need to develop new and innovative performance measures that more accurately capture benefits of operations and ITS projects	• Develop a comprehensive list of performance measures impacts of operations and ITS projects, including travel time reliability, customer satisfaction, safety, and cooperation/coordination with other agencies. Develop definitions and methodologies for computing performance measures. • Develop guidance on how agencies can set-up a system for monitoring system performance • Develop mechanisms/tools for reporting/displaying performance measures
Institutional	• There is a need to change the cultural environment from “project-oriented” to “program-oriented”	• Develop briefing material that illustrate impacts of what would happen to system reliability is if don’t make operational improvement or have operations-oriented program as opposed to trying to quantify level of capacity enhancement for operational projects. • Provide dedicated funding for ITS and operations-oriented projects. • Establish categories for funding in TIP and LRTP. Make projects compete for funding within same funding categories (i.e., capacity-enhancement projects compete only with other capacity-enhancement projects) • Develop methods for ensure equity of funding among all agencies in metropolitan area • Develop measures of quantifying impacts of benefits that cross agency boundaries

Category	Description of Need	Potential Actions to Address Needs
Education	• There is a general lack of understanding about the capability and limitations for the different types of evaluation tools.	• Develop a catalog that shows the different capabilities and limitations of the evaluation tools. • Use national teleconference to discuss issues related to conducting evaluations. • Create a clearinghouse where practitioners can post and locate information on use cases, benefits, and experiences with different tools. • Develop of synthesis of practice • Develop an NHI training course that provides a standard methodology for modeling benefits. The target audience for this training should be those that are mid-career and are responsible for performing the evaluations. • Provide training opportunities at AASHTO, AMPO, ITS America, ITE annual meetings. • Provide cross-training opportunities for operations personnel on developing effective projects for inclusion in TIP
	• There is a need to inform elected officials and decision-makers on the benefits and importance of operations-oriented and ITS projects.	• Examine alternative measure for reporting and assessing the effectiveness of the performance of operational improvements. • Create briefing materials that show the importance and benefits of operations
Data Requirements	• There is a lack of quality data that show the system-wide impacts of events	• Obtain more accurate benefits and costs information about system-wide impacts of ITS and operations-oriented projects. • Identify boundaries in determining benefits – what are the local impacts vs. the system impacts. • Provide local data wherever possible but also provide data from locations of similar size, network topology, geography, and traffic characteristics. • Develop a guidance document that shows users how to find or adjust known benefits and cost information to more closely meet local conditions. • Develop a methodology for capturing impacts of system-wide programs

Category	Description of Need	Potential Actions to Address Needs
		as opposed to individual projects. • Provide full instrumentation of entire network to allow better monitoring and comprehensive data bases
	• There is a need to develop a common language and share data between operations and planning personnel.	• Create standard for exchanging data between operations and planning • Create a catalog of data requirements commonly used by operations and planning evaluations • Create common definitions and meaning for the data used by operations and planning
	• There is a lack of good "before and after" studies that quantify the impacts of ITS projects	• Provide local data wherever possible but also provide data from locations of similar size, network topology, geography, and traffic characteristics. • Develop a standard reporting mechanism that users can use to provide benefit and cost information. • Create a clearinghouse where practitioners can post and locate information on use cases, benefits, and experiences with different tools. • Expand upon the available number and types of use cases.
	• Many agencies are using the tools only to quantify the economic benefits of projects. There is a need to have examine how operational projects can be sequenced over time to generate long-range improvements	• Develop a standard methodology for conducting evaluations of ITS and operations-oriented projects. Don't be constrained by model type, but focus on methodology. • Develop an analysis tool that performs a tradeoff analysis of alternatives and identifies sequence of improvement that maximizes incremental benefits (i.e. develops a program and staging of improvements for long-term). • Develop an analysis tool that examines the effects of sequencing operations improvements in conjunction with capital improvements
Analysis Tools / Techniques	• Tool developers need to be cognizant of time constraints and data accessibility requirement of users. Many agencies do not have the time to full evaluation of many different alternatives	• Develop mechanism whereby archived operations data can be fed directly into evaluation tools. • Develop a user-interface that allows user to select different alternatives for inclusion in alternatives analysis. • Develop analytical tool that allows quick screening of alternatives, and then allow users to perform more detailed analysis of alternatives (maybe an integration of IDAS and
	• It is difficult to anticipate driver behavior in response to improvements.	• Conduct research that examines how driver behavior changes in response to different operational strategies (especially traveler information systems) • Incorporate driver behavior effects into analysis tools
	• Analysis tools do not consider impact of projects on long-term operational	• Develop methodology / guidance on how different operational improvements impact local agency resources – in terms of full-time

Category	Description of Need	Potential Actions to Address Needs
	resources	equivalent employees, staff capabilities, etc.
	• There is a need to quantify impacts of operations project on air quality conformance and customer satisfaction/ customer service	• Incorporate methods for quantifying air quality impacts • Change "rules" to allow agencies to obtain air quality credits for performing operational improvements • Incorporate methods for assess impacts of operations-oriented and ITS projects on customer satisfaction or ability of agency to provide customer service.
Performance Measures	• There is a need to develop new and innovative performance measures that more accurately capture benefits of operations and ITS projects	• Develop a comprehensive list of performance measures impacts of operations and ITS projects, including travel time reliability, customer satisfaction, safety, and cooperation/coordination with other agencies. Develop definitions and methodologies for computing performance measures. • Develop guidance on how agencies can set-up a system for monitoring system performance • Develop mechanisms/tools for reporting/displaying performance measures
Institutional	• There is a need to change the cultural environment from "project-oriented" to "program-oriented"	• Develop briefing material that illustrate impacts of what would happen to system reliability is if don't make operational improvement or have operations-oriented program as opposed to trying to quantify level of capacity enhancement for operational projects. • Provide dedicated funding for ITS and operations-oriented projects. • Establish categories for funding in TIP and LRTP. Make projects compete for funding within same funding categories (i.e., capacity-enhancement projects compete only with other capacity-enhancement projects) • Develop methods for ensure equity of funding among all agencies in metropolitan area • Develop measures of quantifying impacts of benefits that cross agency boundaries

TAXONOMY OF USER NEEDS
A taxonomy is defined as the follow:

> *"A scheme that partitions a body of knowledge and defines the relationships among the pieces."*

Taxonomies are generally used to classify and understand a body of knowledge, and can provide order and structure to large issues and topics. Perhaps the most readily recognized taxonomy is the one used to classify organisms. In this taxonomy, plants and animals are classified and grouped according to their similarities of structure or origin.

As part of this portion of the project, we were tasked with developing a taxonomy of user needs for evaluating operations and ITS projects in the planning process. What we attempted to do in our taxonomy was to identify and group the user analysis needs according to spatial, temporal, and policy levels. We began by identify some to the major type of transportation improvements commonly included by agencies in their transportation plans, and identified and grouped analysis needs according to the following classifications:

- Spatial Analysis Needs – These represent the types of analysis needs that agencies might have assessing different operational strategies. We further subdivided these analysis needs into Facility Level, Corridor Level, and the Regional Level needs to reflect the different types of analysis that need to be performed for each strategy.
- Temporal Analysis Needs - These define the analysis needs of agencies might require to assess the type of improvement at over different timeframes. These analysis needs were divided into Present Day, Intermediate and Long-range analysis needs.
- Policy Level/Operational Philosophy Analysis Needs -- These represent the types of analysis needs that agencies might pursue to address policy level decisions.
- Issue Affecting Implementation – With each type of improvement, we also attempted to identify some of the issues that agencies might need to evaluate before implementing a particular type of improvement.
- Potential Performance Measures – For each strategy, we also identified candidate performance measures that could be used to assess the effectiveness in an analysis of a strategy. These were further broken down into performance measures related to following goals:

    - Improved System Operations,
    - Improved Safety,
    - Improved Customer Satisfaction / Relations,
    - Improved Agency Efficiency, and
    - Reduced Vehicle Emissions and Fuel Consumption.

- Data Needs – For each strategy, we also identify some primary and secondary data needs that would be required to conduct an assessment of the operational strategy
- Relationship with Other Systems – This identify some of the other systems that are required or needed to implement the operational strategy.

The following tables show the application of this taxonomy to common operational and ITS strategies employed in metropolitan areas.

Automatic Vehicle Locating Systems • Primarily used to provide vehicle location information on transit vehicles, but can also be used to locate emergency vehicles • Needed to support other traffic and transit management functions such as transit signal priority, automatic scheduling and schedule adherence systems, transit traveler information (next vehicle arrival) systems, transit security systems, etc. • Generally, these systems are implemented over time. The timeframe of the installations depends upon size of fleet on which AVL is being deployed and available funds.		
Spatial Analysis Needs	• Facility Level	• Identify locations for placing signposts for vehicle information to be sent back to management system. • Assess power and communications availability
	• Corridor Level	• Assess number of vehicles from the fleet required to provide desired level of coverage in the corridor • Assess the needs for integrating tracking system with other transit operational strategies currently existing and/or planned for the corridor • Assess the capabilities of available communication alternatives in the corridor.
	• Regional Level	• Select either vehicle- or roadside-based technology design • Assess capabilities of current communications system • Assess communication requirements of tracking system alternatives • Identify opportunities to integrate location information with other operational strategies, such as transit signal priority, transit information systems, electronic fare payment systems, etc. • Assess needs to improve management and supervision of transit services, including the capabilities of the transit management center
Temporal Analysis Needs	• Present Day	• Identify improvement needs for management and supervision of transit service • Identify upgrade and/or replacement needs for aging radio system • Assess capability of technology choice to be integrated with existing vehicle fleet
	• Intermediate	• Assess the availability of opportunities to integrate bus information with other operational strategies, such as transit signal priority, transit information systems, electronic fare payment systems, etc. • Determine the need for better operational support of transit services, such as dynamic route scheduling, etc.
	• Long-Range	• After initial deployment of system, agencies would need to incorporate AVL equipment as new vehicles are introduced into fleet. May experience system compatibility issues over long-term, especially with phased implementations of new transit vehicles. • Determine agency desired long-range operational goals, such as implementing zone-

		based or distance-based differential fare pricing system
Policy Needs / Operating Philosophy	• Coupled with other management functions	• AVL by itself does not provide much functionality, but is necessary to support of functions such as transit signal priority, automatic scheduling and schedule adherence systems, transit traveler information (next vehicle arrival) systems, transit security systems, etc.
Issues Affecting Implementation	• Vehicle–based vs. Roadside-based deployment	• Two methods of deployment – vehicle-based or roadside-based. Method of deployment affects infrastructure needed to support deployment. For example, vehicle-based may require upgrade to transit-radio system. Roadside deployment require communication infrastructure to get information back to transit management center.
Performance Measures	• Improved system operations	• % of vehicles adhering to schedule
	• Improved safety	• Increases in the effective tracking of off-route buses • Reduction in response time of emergency responders by having more accurate vehicle location
	• Improved customer satisfaction/relations	• Reduced customer and operator complaints
	• Improved agency efficiency	• Improved ability of dispatchers to control bus operations • Facilitate on-street service adjustments • Increased accuracy in schedule adherence monitoring and reporting • Effective tracking of paratransit vehicles and drivers • Eliminate need for additional road supervisors • Reduce manual data entry
	• Reduced vehicle emissions and fuel consumption	None Identified
	• Promote multimodal operations	• Decrease in passenger delays due to more efficient transfer coordination
Data Requirements	• Primary	• Fleet size • Phasing of deployment • Identification of routes or types of transit service to be supported (local vs express)
Relationship with Other Improvements	• Transit Signal Priority • Automatic Scheduling • Emergency Management	• AVL can be used to identify transit vehicle in need of priority • Provide method to automatically collect schedule adherence information and identify impediments to scheduling

Electronic Toll Collection Systems (ETCS) • Allows for the automatic collection of vehicle tolls while traveling at or near highway cruising speeds. • Use vehicle-to-roadside communications technology to perform an electronic monetary transaction between a vehicle and atoll station		
Spatial Analysis Needs	• Facility Level	• Identify the number of "readers" installed at each toll collection location • Assess mechanism for connecting to communication network • Determine the placement of field devices for optimal operations and maintenance • Assess data management/handling strategies
	• Corridor Level	• Identify locations for installing ETCS • Establish common infrastructure for providing communication at each corridor location • Assess ability and capabilities to reduce labor costs of staff to operate toll collection plazas
	• Regional	• Determine collection and distribution centers and communication linkages between toll agencies in region. • Examine interoperability and compatibility with other systems that may already exist within region/state. • Determine existence, capabilities, and expandability of the communication infrastructure. • Identify opportunities, ease, and added functionality achieved by integrating with other traffic management and information systems • Assess the presence and capabilities of toll collection and billing network • Analyze the market penetration for utilizing an ETCS
Temporal Analysis Needs	• Present Day	• Determine the volume of transactions • Assess the enforcement capabilities and requirements • Analyze the privacy and security of information and transactions
	• Intermediate	• Determine the availability of system data to support operations • Examine the interoperability with other systems that may already exist or are planned in region and/or state • Evaluate scalability of technology to other facilities in region • Examine conformity of technology to existing or emerging standards
	• Long-Range	• Evaluate the maintenance and replacement requirements of technology • Evaluate scalability across region • Analyze communication infrastructure needs and demands • Map evolution of technology
Policy Needs	• Secondary Applications	• Use of technology for other purposes, such as surveillance and detection
Issues Affecting Implementation	• Technology	• ETC technology fairly mature. Compatibility and interoperability issues between systems by different vendors exist, especially with older technologies.
	• Institutional	• Standardization of technology • Administrative and technical interoperability of systems.

		• Privacy issues related to traffic monitoring function
Performance Measures	• Improved system operations	• Increase in toll lane and toll plaza capacity • Reduction in motorist wait times at toll plazas
	• Improved safety	None Identified
	• Improved customer satisfaction / relations	• Increases in convenience for toll payers
	• Improve agency efficiency	• Reduction in toll collection costs • Enhancement of audit control by user accounts
	• Reduced vehicle emissions and fuel consumption	• Fuel savings and a decrease in mobile emissions by reducing or eliminating waiting times • Reductions in point-source emissions due to higher vehicle speeds
	• Promote multimodal operations	None Identified
Data Requirements	• Primary	• Number of lane miles of toll roads in region • Type and market penetration of existing ETCS in region • Number and location of toll plazas
Relationship with Other Improvements	• Surveillance and Detection	• Readers have been installed on non-toll facilities and information has been used to develop link travel times between readers

Electronic Fare Collection Systems (SMART Card) • Technology to provide for the automatic collection and distribution of fares and other user fees • Objective is to provide travelers with a common fare medium across all transportation service, including transit, parking, ferries, and other modes. • Capable of implementing variable and flexible fare structure to promote mode shift and reward costumer loyalty		
Spatial Analysis Needs	• Facility Level	• Determine location, placement, and signing for customer service centers and kiosk.
	• Corridor Level	None Identified
	• Regional Level	• Assess capabilities of payment system to provide mechanism for payment for other city services (e.g., library, swimming pools, parking, etc.) • Evaluate equity and timeliness of reconciliation and distribution of revenues collected in a multi-operator system • Determine capability of fleet vehicles for installation of technologies • Examine capabilities of communication systems at management center • Identify processing needs and capabilities at management center
Temporal Analysis Needs	• Present Day	• Select initial electronic fare collection system technologies for deployment • Identify opportunities for achieving integration between transit providers in region, if system already implemented • Assess the age of vehicle fleet and plans to replace vehicle fleets • Evaluate ridership levels, passenger demands and satisfaction of fare payment system
	• Intermediate	• Identify other transportation partners for producing economies of scale • Identify opportunities to use system to provide variable or flexible fare structure to provide ridership increases and rewards for customer loyalty
	• Long-Range	• Identify opportunities for expansion beyond transit fares to include electronic toll payment, payment of parking fees, phone calls, retail purchases, etc.
Policy Needs	• Secondary Applications	• Use of payment system to provide mechanism for payment for other city services (e.g., library, swimming pools, parking, etc.) • Use as an exclusive payment system or in combination with traditional coin-box system
	• Promoter Intermodal operations	• Promotes seamless transportation as travelers use payment system on multiple modes
Issues Affecting Implementation	• Technology	• Many different types of technologies are available including “contact” fare cards; RF “proximity” cards; “integrated circuit smart cards’; and “m-commerce” applications. Technology is rapidly changing.
	• Integration	• Different technologies and deployments coupled with complexities of banking system and concerns over privacy have created interoperability and compatibility obstacles. • Standards have been developed to potential address interoperability among fare card systems.

		• Integration with other systems such as electronic toll collection, parking payment systems, etc.
Performance Measures	• Improved system operations	• % improvement in travel time reliability of transit vehicles by eliminating loss time and delays due to cash handling • Reduction in average transit boarding times
	• Improved safety	None Identified
	• Improved customer satisfaction/relations	• % change in customer convenience rating • % change in customer satisfaction rating
	• Improve agency efficiency	• Reduction in revenue collection costs • % increase in additional revenues generated • % reduction in service payment abuse and evasion • Improved equity and timeliness of reconciliation and distribution of revenues collected in a multi-operator system
	• Reduced vehicle emissions and fuel consumption	• Reductions in point-source emissions due to reduced idling time at transit stops
	• Promote multimodal operations	• Number of multimodal trips • % change in ridership on high-occupancy vehicles by promoting easy transfers
Data Requirements	• Primary	• Number of transit vehicles • Type of current payment method • Volume of transactions
	• Secondary	• Cost savings of reduced personnel requirements to collect fares
Relationship with Other Improvements	• Transit Management	• Collect ridership/origin-destination patterns and boarding demands at stops and transfers

Toll Facilities • A quasi-public facility that uses the collection of fees to retire the debt of constructing the roadway and to provide funding for ongoing operations and maintenance • May require legal and institutional framework to permit the collection of tolls • There are a number of pricing strategies, such as flat tolls, variable tolls, etc., that need to be evaluated to determine the most appropriate strategy for a particular facility		
Spatial Analysis Needs	• Facility Level	• Analyze the placement and design of individual toll plazas. • Determine the location and level of enforcement needs • Analyze the price structure for tolls to cause shifts in demand
	• Corridor Level	• Assess shift in travel demand to other facilities/modes, especially if toll increased during peak periods • Assess right-of-way requirements and costs to provide tolling operations
	• Regional Level	• Identify the personnel and staffing requirements to support tolling operations • Assess the institutional arrangements for collecting and distribution toll revenues
Temporal Analysis Needs	• Present Day	• Assess impact on traffic operations and revenue generation of different toll pricing structures on existing facilities
	• Intermediate	• Predict associated annual revenues that could be generated for specified period from tolling a proposed project
	• Long-Range	• Identify need for future toll facilities based on projected traffic demands and the potential for revenue generation • Assess availability, proximity and congestion levels of alternate free or non-tolled facilities
Policy Needs	• Use of Toll Revenues	• Examine opportunities to use toll revenues to support operations and maintenance of facilities, even after the construction debt has been retired.
	• Secondary Applications	• Use of toll road traffic information for other purposes, such as regional traffic management and traveler information
Issues Affecting Implementation	• Public acceptance	• Public experience and acceptance of toll concept; marketing campaign is needed to improve public understanding of the reasons for tolling
	• Technology	• Variety of technology and mechanisms for toll operations. Compatibility and interoperability issues between systems by different vendors exist, especially with older technologies.
	• Institutional	• Standardization of technology • Administrative and technical interoperability of systems. • Privacy issues related to traffic monitoring function
Performance Measures	• Improved system operations	• Travel time savings • Reduction in travel time variability

		• % of hours non-toll facilities operate at congested levels
	• Improved safety	None Identified
	• Improved customer satisfaction/relations	• Improved public perception of congestion levels • Increased levels of convenience by trips serviced by toll facility
	• Improve agency efficiency	• Increases in the amount of revenues collected • % of operating budget used to maintain and operate facility
	• Reduced vehicle emissions and fuel consumption	• Fuel savings and a decrease in mobile emissions by reducing or eliminating waiting times • Reductions in vehicle emissions due to higher vehicle speeds
	• Promote multimodal operations	None Identified
Data Requirements	• Primary	• Travel demand patterns • Trip lengths • Planned and desired urban growth patterns
	• Secondary	• Planned and programmed develop of alternative transportation systems, such as freeways, transit facilities, etc.
Relationship with Other Improvements	• Electronic Toll Collection • Surveillance and Detection • Traveler Information	• Use of ETC can improve efficiency and enforcement of toll collections • Infrastructure for toll lane management can be used to support other traffic management purposes • Toll road information is often included with information about other transportation alternatives in the region to provide comprehensive picture of the status of the transportation system.

Variable Toll Facilities • Also referred to as "value pricing" • Generally implemented on existing toll facility • Amount of toll varied by time-of-day with intention of encouraging some travelers to use facilities during less congested period or to shift to other modes or routes. • By causing demand to shift, the need for additional capacity on facility can be deferred or eliminated.		
Spatial Analysis Needs	• Facility Level	• Identify and assess existing operational bottlenecks where variable tolling might be appropriate (e.g., bridges, tunnels, etc.) • Assess travel demands and origin-destination patterns • Assess the availability of excess capacity by time-of-day on the facility • Location and requirements of enforcement operations
	• Corridor Level	• Assess the ability to shift in travel demand to other facilities/modes, especially if toll increased during peak periods • Origin-destination patterns in the corridor for diversion potentials • Price elasticity • Projected land use and development pattern in corridor
	• Regional Level	• Projected origin-destination patterns in the region. • Long-range projected land use (existing and future) and development patterns in the region.
Temporal Analysis Needs	• Intermediate	• Identify periods of excess demand by time-of-day • Identify periods where spare capacity exists by time-of-day • Assess opportunities for variable pricing to shift excess demand to available capacity
	• Intermediate	• Analysis of projected travel demand and development patterns to identify when in future variable tolling may be required
	• Long-Range	• Monitor regional travel demands to identify facilities/corridors that might benefit of variable toll facilities
Policy Needs	• Tolling Strategy	• Two implementation strategies: 1) reduce tolls on "shoulder" periods immediately before or after the peak period or 2) increase tolls during peak periods. Latter strategy perceived as placing increased cost burden on motorists and ignores difficulty some travelers have in changing the time that they can use facility.
Issues Affecting Implementation	• Public Acceptance	• Public experience and acceptance of variable toll concept; marketing campaign is needed to improve public understanding of the reasons for variable tolling
	• Enforcement	• Agencies need to determine how they are going to manage users who are already on facilities when price changes
Performance Measures	• Improved system operations	• % reduction in peak period time • % reduction in peak period demand

		• % reduction in number of hours tolling facility is operating in congestion • % reduction in travel time variability • Increase in average travel speeds
	• Improved safety	• % reduction in congestion-related crashes during peak period • % change in crash rate during non-peak (or shoulders of peak)
	• Improved customer satisfaction/relations	None Identified
	• Improve agency efficiency	• Increased in revenue generated by tolling
	• Reduced vehicle emissions and fuel consumption	• Reduction in peak period emission due to increase travel speeds
	• Promote multimodal operations	• Increase in the formation of high occupancy vehicle groups (vanpools, etc.) • Increase in transit ridership
Data Requirements	• Primary	• Traffic flow/congestion level by time-of-day • Price elasticity for lane usage
	• Secondary	• Proportion of users that have flexible trip time requirements
Relationship with Other Improvements	• Electronic Toll Collection • Traveler Information Systems • En-route Driver Information Systems	• ETCS allows agencies to have flexibility to change tolling rates as demands warrants • Need to provide capabilities of communicating current toll rate to users

High-Occupancy Toll (HOT) Lanes • Low occupancy vehicles are charged a toll to use High-Occupancy Vehicle (HOV) facility. • Vehicles not meeting HOV criteria are essentially allowed to buy the right to use the HOV lane. • HOT lanes use price to manage demand in HOV lanes – price provides additional criteria of eligibility to use HOV lane: vehicles with certain minimum occupancy plus those willing to pay toll.		
Spatial Analysis Needs	• Facility Level	• Identify physical constraints, including cross section limitations and right of way restrictions that may impact the type of strategy that can be used.
	• Corridor Level	• Identify facilities that could potential benefit from variable tolls or HOT lanes.
	• Regional Level	• Assess impacts of implementing network of toll facilities, either through new construction or through conversion of existing facilities
Temporal Analysis Needs	• Present Day	• Fine-tune tolls to find the appropriate price to generate sufficient additional demand to utilize spare capacity of HOV lane
	• Intermediate	• Estimate when demand might require change in operating strategy of HOV lanes given immediate past changes in demand. • Assess elasticity of toll prices to balance demand for a facility
	• Long-Range	• Determine the ability to defer construction of additional capacity by maximizing person throughput in HOV lane
Policy Needs	• Demand Management	• Establish target capacity and level of service to be maintained in the HOV lane
Issues Affecting Implementation	• Enforcement	• Measuring the number of occupants in vehicle is very labor intense. There is a need to develop technologies that can measure occupancy levels of vehicles automatically.
Performance Measures	• Improved system operations	• % increase in vehicle-carrying capacity • % increase in person-carrying capacity • % change in free flow speed • % reduction in vehicle travel times
	• Improved safety	None Identified
	• Improved customer satisfaction/relations	• Perceived advantage over general travel lanes
	• Improve agency efficiency	• Increased revenue generated by tolling
	• Reduced vehicle emissions and fuel consumption	• Improve air quality from mobile sources
	• Promote multimodal operations	• Increase in the formation of high occupancy vehicle groups (vanpools, etc.) • Increase in transit ridership
Data Requirements	• Primary	• Composition of traffic stream in HOV lane by vehicle occupancy level • Capacity of HOV lane at desired level-of-service • Price elasticity

Relationship with Other Improvements	• Electronic Toll Collection Systems	• ETCS allows agencies to have flexibility to change tolling rates as demands warrants

Signal Control and Priority (SCP) • Method of providing preferential treatment to transit and emergency vehicles at signalized intersections. • Emergency vehicle receive higher priority than transit vehicles • Intended to improve service and trip time reliability		
Spatial Analysis Needs	• Facility Level	• Assess operational impacts of SCP on intersection operations • Assess changes in approach and intersection delay • Determine placement of detection devices • Identify signal timing strategy
	• Corridor Level	• Assess impact of SCP on transit and emergency service (especially schedule adherence, transit running time, running time reliability, response times) • Determine vehicles eligible for priority (e.g., Bus Rapid Transit (BRT) or express bus service in high transit demand corridor; fire, ambulance, police for emergency vehicles) • Establish criteria for granting priority • Identify intersections for installing SCP equipment
	• Regional Level	• Quantify impacts of implementing SCP on overall quality service (e.g., increase in ridership levels, customer satisfaction, emergency response times, etc.) • Identify routes to implement priority
Temporal Analysis Needs	• Present Day	• Evaluate potential deployment options and strategies in corridor or at intersection • Fine-tune operational criteria for granting priority treatment
	• Intermediate	• Identify routes / corridors that could potentially benefit from SCP
	• Long-Range	• Assess how improvement might delay the need to add capacity to corridor by moving more people (not vehicles) through corridor
Policy Needs	• Preemption vs. Priority	• Priority provides preferential treatment without disrupting traffic signal coordination • Preemption provides preferential treatment without regard to operations of signal. • Disruption to signal timing and traffic flow patterns at intersection less severe with priority control than preemption.
	• Level of Priority	• Emergency vehicle generally receive higher priority because of critical nature of service.
Issues Affecting Implementation	• Level of system intelligence	• There are different degrees of sophistication with transit signal priority. Simplistic systems grant priority to all transit vehicles, regardless of need. More sophisticated system use schedule adherence or "time budgets" to grant priority only to those vehicles in need of preferential treatment (i.e., those vehicles behind schedule). As the level of sophistication increases, the infrastructure and communications system to support complexity increases, but the amount disruption to normal traffic flow decreases as sophistication increases.
Performance Measures	• Operational Efficiency	• % improvement in transit schedule adherence • % improvement in emergency response time • Reduction/change in transit vehicle running times

		• % improvement in transit or emergency vehicle running time variability • Reduction in person delay
	• Safety	None Identified
	• Improved customer satisfaction/relations	• Improved on-time performance of transit vehicles
	• Improve agency efficiency	None Identified
	• Reduced vehicle emissions and fuel consumption	• Reduction in operating costs/fuel costs for transit agency) • Number of SOV vehicles replaced because of increased ridership
	• Promote multimodal operations	• Increase in transit ridership level • Time delayed needed to add capacity to facility or corridor
Data Requirements	• Primary	• Number of transit and emergency vehicles in fleet • Number of intersections on routes • Route information • On-time / response time goals of transit and emergency vehicles
Relationship with Other Improvements	• Vehicle Locating Systems	• The ability to provide SCP is greatly enhance with vehicles equipped the AVL

Traffic Actuated Signals • Switching from fixed or pre-timed, time-of-day control to traffic actuated control • Switching from semi-actuated to full actuated control • The impacts can be regional if the agency is transitioning from an area-wide pretimed/ fixed time-of-day type operation to fully actuated control, where traffic flow is optimized at local intersections.		
Spatial Analysis Needs	• Facility	• Assess the type and capabilities of the existing controllers • Determine the amount and approach locations of vehicular delay • Identify the presence and location of malfunctioning or missing detectors • Assess the geometric and environmental conditions that might influence detection capabilities • Assess the type and potential causes of vehicle collisions • Assess the need to provide special operations for transit, railroad grade crossings, fire stations, etc. • Determine the location, design, and placement of auxiliary lanes and driveway access points
	• Corridor	• Assess the variability of flow patterns by direction and time-of-day • Determine the need to provide progressive movement to through movements in corridor • Assess the need for special operating characteristics such as the need for rail, transit, or emergency vehicle preemption in the corridor
	• Regional	• Assess the ability to provide a comprehensive maintenance program to upgrade or repair malfunctioning traffic detection systems. • Identify high traffic congestion growth areas
Temporal Analysis Needs	• Present Day	• Assess intersection performance (delay, accidents, etc.) • Examine the characteristics of vehicular arrival patterns. The analysis should not be peak periods only, but also include the remainder of the day, because in peak-periods where traffic demands are heavy, actuated traffic signals tend to operate as fixed-time signals. Very small changes in traffic signal timing plans generally occur during peak periods. • Examine the need to provide special control for vehicle with unique operating characteristics (heavy trucks, transit, etc.) • Examine the crash histories in the past year
	• Intermediate	• Assess the ability of agencies to periodically review and re-optimize signal timing plans throughout region (e.g., once very 3 years as recommended by ITE). • Examine issues related to expansion of system and traffic demands in response to growth patterns
	• Long-Range	• Determine the ability of agencies to provide long-term support and upgrades to increase traffic detection and surveillance requirements

Policy Needs / Operating Philosophy	• Overall Signal Performance	• Determine public perception of the overall performance of traffic signals. • Assess the potential improvement (in terms of system-wide delay reduction) of upgrading or retiming traffic signals
Issues Affecting Implementation	• Level and capability of detector / surveillance system.	• Actuated traffic signals highly effective as long as detection / surveillance system is functioning properly. Inoperative or malfunctioning detectors force agencies to operate signal with a fixed timing plan; therefore negating the benefits of actuated control. • To achieve long-lasting benefits from switching to actuated controls, agencies must also commit to comprehensive program to replace and repair malfunctioning detection systems.
Performance Measures	• Improved system operations	• Reduce intersection control delay • Increase in system-wide delay savings
	• Improved safety	• Reduction in accident frequency • Reduction in accident rate
	• Improved customer satisfaction/relations	• Reduce the number and percentage of stops • Reduce the average number of times stopped in single trip through corridor • Reduce the number of hours per day operating at or below LOS E or desired speed
	• Improved agency efficiency	• Reduction in the number of citizen complaints and trouble reports
	• Reduced vehicle emissions and fuel consumption	• Reduction in vehicle emissions • Fuel savings
	• Promote multimodal operations	None Identified
Data Requirements	• Primary	• Turning movement volumes • Approach volumes • Intersection geometries • Current phasing or timings
	• Secondary	• Crash histories • % of current intersection actuated
Relationship with Other Improvements	• Surveillance • Transit Operations • Emergency Management	• Traffic actuate signal require greatly expanded surveillance and detection capabilities • Provide for more efficient operations, especially when incorporating signal control and prioritization

Traffic Signal Coordination • Involves coordinating the operations of multiple signals on an arterial or in a network to provide for the progressive flow of traffic • Control objective is to pass platoons of vehicles from one intersection to the next at a prevailing travel speed without requiring them to stop.		
Spatial Analysis Needs	• Facility Level	• Assess intersection spacing, intersection geometries, and travel speeds • Assess traffic distributions (i.e., through versus turning movements) • Assess availability of communications infrastructure • Assess impact of operating signal with common cycle length
	• Corridor Level	• Identify critical control intersections (i.e., intersections that control the establishment of coordination timing plans) • Identify limits of coordination in corridor (i.e., number of intersection through which to provide coordination)
	• Regional Level	• Assess the need for centralized versus decentralized control • Assess the need for network versus corridor control
Temporal Analysis Needs	• Present Day	• Identify number of distinct traffic flow patterns. This determines the number of required timing plans and need for traffic responsive control)
	• Intermediate	• Assess the ability of the existing traffic control system to handle the impacts of anticipated traffic growth in corridor
	• Long-Range	• Examine the potential to integrate with regional traffic management systems, such as transit signal priority, freeway management system, etc.
Policy Needs / Operating Philosophy	• Conflicting policies	• Examine the effects of policy decisions, such as speed management techniques, have on travel time performance. Signal progression is a function of the desired travel speed on a corridor. The desire to reduce travel times may require agencies to time traffic signals to provide a higher travel speed on an arterial. Higher speeds may not be desirable across all user groups.
Issues Affecting Implementation	• Method of coordination – Time-based vs. Interconnected	• In time-based control, coordinating the operation of the signals is achieved through the used of a time clock internal to the controller. With this method of coordination, timing plans are synchronized according to the clock. With interconnected signal, coordination in achieved through a physical communication link (i.e., copper wire, coax cable, fiber-optic cable, RF) and a synchronization pulse is used to keep signals in step with one other. Because of drifting problems with the internal clocks, interconnect provides more stable operation; however, interconnection requires installation of communication network.
	• Mode of Operation – Time-of-Day vs. Traffic Responsive	• With time-of-day control, coordination plans are selected based upon the time of day. In the traffic responsive mode, coordination timing plans are selected based upon measured traffic demands. With traffic responsive, coordination plans more closely

		match existing traffic patterns; however, traffic responsive mode requires installation and calibration of system detectors to measure changes in traffic patterns. Furthermore, traffic responsive control can only be provided with interconnected systems.
	• *Background Signal Operations* – Fixed time vs Actuated Control	• Even in coordinated operations, individual traffic signals can be setup to be traffic actuated. With actuated coordinated control, the overall background timing plan remains fixed with the constant cycle length, but individual phase durations can be adjusted be meet measured demand.
	• *Type of Control* – Centralized vs. Decentralized	• In centralized control, data from all individual intersections is feed back to a central computer that makes a decision on the control of the signal. With decentralized control, groups of intersections are controlled by a field master, which makes control decisions about timing plans to implement. Centralized control requires a more extensive communication network as well as a computing power at a central location (usually a TMC). Decentralized control requires additional hardware to be installed in field.
Performance Measures	• Improved system operations	• Reduction in average travel speed in corridor (by direction) • Reduction in average travel time in corridor (by direction) • Reduction in travel time variability (by direction) • Increases in system throughput
	• Improved safety	• Reduction in accident frequency • Reduction in accident rate
	• Improved customer satisfaction/relations	• Reduction in number and percentage of stops • Reduction in average number of times stopped in single trip through corridor • Reduction in number of hours of day operating at or below LOS E or desired speed
	• Improved agency efficiency	• Reduction in the number of citizen complaints and trouble reports
	• Reduced vehicle emissions and fuel consumption	• Reduction in vehicle emissions • Increases in fuel savings
	• Promote multimodal operations	None Identified
Data Requirements	• Primary	• Corridor travel times and desired travel speeds • Directional flow patterns • Arterial network geometries
	• Secondary	• Capabilities of existing control equipment • Location of potentially politically sensitive areas
Relationship with Other Improvements	• Surveillance • Transit Operations • Emergency Management	• Traffic responsive mode requires greatly enhanced surveillance capabilities over time-of-day control • Use of preemption and priority for rail, emergency, and transit may affect ability to provide coordinated control

Adaptive Traffic Signal Control (ATSC) • Highest level of system control for traffic signals, but a relatively new technology • Uses real-time data from detectors to perform constant optimizations of signal timing plans for an arterial or network. • Useful in managing all levels of traffic, including non-recurring congestion, incidents, events, or growth in traffic demand • Includes some level of short-term prediction of traffic demands so that signal timings can be proactive and opposed to reactive. • Requires greatest level of detectorization • Limited amount of actual field deployments with measurable results		
Spatial Analysis Needs	• Facility Level	• Assess surveillance and detection capabilities • Assess capabilities and functionality of controller equipment • Assess travel demand patterns
	• Corridor Level	• Assess the capabilities to provide interrelated communications between adjacent signals
	• Regional Level	• Identify corridors where ATSC provides higher potential for more efficient operations over traditional coordination schemes.
Temporal Analysis Needs	• Present Day	• Identify facilities that exhibit highly fluctuating traffic demands on a cycle by cycle basis
	• Intermediate	• Determine when and how fluctuations in traffic demands might change in response to changing patterns.
	• Long-Range	• Evaluate the long-term effectiveness of ATCS. There are limited number of actual field deployments, especially for Rhodes, OPAC, etc.
Policy Needs / Operating Philosophy	• Commitment of Resources	• Examine the ability of agencies to commit the resources required to install, operate, and maintain ATSC implementations. An agency must be willing and able to provide high level of commitments for training, staffing, installation and maintenance of detectors, etc.
Issues Affecting Implementation	• New Technology	• Adaptive Traffic Signal control is still in its infancy with the majority of installation being SCOOT or SCAT type of installations. Still have trouble with hardware and software installations and implementations. Very little evaluation data available.
Performance Measures	• Improved system operations	• Reduction in delay or vehicle-hours traveled
	• Improved safety	• Reduction in accident rate
	• Improved customer satisfaction/relations	None Identified
	• Improved agency efficiency	• Reduction in the frequency at which wholesale signal timing updates are needed
	• Reduced vehicle emissions and fuel consumption	• Reduction in vehicle emissions • Reduction in fuel consumption

	• Promote multimodal operations	None Identified
Data Requirements	• Primary	• Operational parameters and characteristics of current signal system • Fluctuation in intersection and corridor traffic demands • Results for actual field deployments
	• Secondary	• Level of surveillance and communication between signals
Relationship with Other Improvements	• Surveillance and detection • HOV treatments • Transportation Management Center • Traffic Incident Management	• ATSC involves a significant increase in the level and reliability of the detection system

Ramp Metering • This strategy involves the use of a traffic control signal installed on a ramp to regulate the rate at which traffic is allowed to enter the freeway in order to improve traffic flow on the freeway. • The rate may be fixed (pretimed for certain periods, based on historical data) or may be variable (traffic responsive) based on measured traffic parameters.		
Spatial Analysis Needs	• Facility Level	• Assess how the ramp metering system should be designed to operate. Local ramp metering is employed when the conditions are localized to an individual ramp. One or more ramp in a section of freeway may be controlled. Metering rates are set specifically for the local conditions and operations of other ramps are not considered. Requires little or no communications infrastructure. Operating philosophy is to optimize operations in the immediate vicinity of the individual ramp.
	• Corridor Level	• Assess the needs for system-level coordination of ramp meters. With system-level control, metering rate is coordinated on a series of ramps in a section of freeway to optimize flow through entire section. System coordination requires a high level of communications infrastructure. With system coordination, evaluation should be conducted at corridor level, including adjacent surface streets because of diversion potential
	• Regional	• Identify the need for and assess the effectiveness of freeway-to-freeway metering. This type of metering is used at high volume freeway interchanges. The purpose of this strategy is to smooth traffic entering the freeway from another location. Because of the far-reaching effects of freeway-to-freeway metering, it should be considered to have corridor-wide or sub-regional impacts.
Temporal Analysis Needs	• Present Day	• Determine the times-of-day where ramp metering would be beneficial. Most ramp metering systems operate during peak period conditions only and are deactivated during nighttime or light volume conditions.
	• Intermediate	• Determine the need for special ramp metering strategies for special event operations.
	• Long-Range	• Investigate the potential for integrating ramp meter operations with traffic signal system to improve system-wide delay
Policy Needs / Operating Philosophy	• Type of Operations (pre-timed vs. traffic responsive)	• Assess the appropriate type of operations desirable for a corridor or region. In pretimed control, the metering rates are set based on time-of-day. With traffic responsive, metering rates adjust to traffic demands. Higher levels of detectorization and monitoring are required with traffic responsive.
	• Level of Restriction (Restrictive vs. non-	• Assess whether to use restrictive or non-restrictive metering rates. Restrictive ramp metering sets rate below the non-metered ramp volume. It restricts the number of

	restrictive)	vehicle allowed onto the freeway in order to keep traffic flowing on freeway. It forces excess demand to divert to adjacent arterial network. With non-restrictive metering, the metering rate is set equal to the average ramp arrival volume. With non-restrictive metering, ramp queues are smaller and less traffic is likely to divert to the arterial streets. This strategy may not prevent the freeway from breaking down.
	• Queue flushing permitted	• Assess the impacts of flushing ramp queues on freeway performance. Many operating agencies choose to limit the ramp queues such that any backups do not physically interfere with surface street operations or require motorists to wait in a queue for longer than a prescribed time. Once queues have grown to a certain level, ramp meter is briefly de-activated to allow queue to dissipate. Could potentially cause freeway to breakdown.
Issues Affecting Implementation	• Diversion of Traffic	• A major issue that is raised in connection with metering is the potential for diverting freeway trips to the adjacent surface streets. Simulation may make it possible to predict the likely impacts of metering. Factors that enter into the analysis include trip length, queue, length, entry delay, and availability of alternate routes. System-wide restrictive metering may not be suitable for areas where there are insufficient alternative routes or potential political backlash by diverting traffic.
	• Equity	• Equity issues commonly arise associated with ramp metering systems. Ramp metering is often perceived to favor longer trips at the expense of shorter trips. Close-in residents argue that they are deprived of immediate access to the freeway, while suburban commuters can enter beyond the metered zone and receive all the benefits without the ramp delay.
	• Enforcement	• The effectiveness of ramp metering is largely dependent on driver compliance. System effectiveness can only be maintained at a high level if a complementary enforcement program is implemented at the same time. Enforcement needs must be considered and accommodated early in the project development and design stages.
	• HOV operations	• Some areas often employ HOV by-pass lanes at ramp meters to encourage the use of high occupancy vehicles and to reduce total user delay on the freeway.
Performance Measures	• Improved system operations	• Improvement in freeway travel time reliability • Decrease the average ramp delay time • Reduction in user delay in freeway or freeway corridor • Reduction in the number of hours merge operating at LOS F
	• Improved safety	• Percent reduction in ramp merge vehicle crashes
	• Improved customer satisfaction/relations	None Identified
	• Improved agency efficiency	None Identified

	• Reduced vehicle emissions and fuel consumption	• Reduction in vehicle emission and excess fuel consumption
	• Promote multimodal operations	• Reduction in the number of HOVs bypassing ramp meter
Data Requirements	• Primary	• The primary data requirements that are needed to perform an analysis of ramp metering systems include the following: ramp traffic volume demands, mainline volumes, metering philosophy, and metering rate.
	• Secondary	• The secondary data requirements include the ramp geometrics, diversion rates, truck traffic, % capacity improvements, etc.
Relationship with Other Improvements	• Surveillance • HOV treatments • Transportation Management Center • Traffic Incident Management • Planned Special Events • Evacuations	• If located properly, vehicle sensor used from ramp metering can also be used for incident detection and system monitoring. • Preferential treatment of high-occupancy vehicle at metered ramps has been used successfully. • While ramp control system can operate in an isolated manner, the operators in TMC can monitor and actively manage ramps via central control and the communications network. • Ramp metering systems can be used to reduce traffic flow upstream of incidents or manage short-term fluctuations in demand caused by special events and evacuations

Incident Detection • Incident detection is the first part of the incident response process • Tools for improving incident detection include use of automated incident detection algorithms, use of courtesy/service patrols, integrating emergency service dispatch information with traffic agencies, providing telephone call-in numbers, etc. • The goal of incident detection systems is to maximize the number of incidents detected as rapidly as possible while minimizing the number of false detections.		
Spatial Analysis Needs	• Facility Level	• Assess the ability to obtain optimization of detection thresholds • Examine the placement of individual detection devices • Identify the level of connectivity to communication systems
	• Corridor Level	• Assist in the development and evaluate the deployment of incident response plans with response agencies • Assess the capability and performance of different detection technologies (e.g. inductive loops, video detectors, CCTV, etc.) • Examine the required communications infrastructure from field devices to the control center and from the control center to response agencies
	• Regional Level	• Evaluate different methods of detection (computer algorithm, roving patrols, motorist call-in, etc.) • Evaluate linkages to other traffic management functions (e.g., ramp metering, traffic signal system, HOV/HOT lanes, variable pricing lanes, etc.) • Identify required partnerships and agreements
Temporal Analysis Needs	• Present Day	• Fine-tune detection thresholds • Identify high-incident corridors for initial/next deployment
	• Intermediate	• Assess the timeframe for phased deployment of technologies
	• Long-Range	• Assess cost implications of long-term maintenance and operations of incident detection technologies • Assess long-term benefits to travelers of implementing incident detection systems
Policy Needs / Operating Philosophy	• Automated vs. observer-based detection	• Assess the capabilities and tradeoffs of automated verse observer-based detection strategies.
	• Resource Sharing	• The improved level of surveillance required to improve incident detection can also be used to provide additional transportation functions. For example, detectors can also be used to provide information for ramp metering systems
Issues Affecting Implementation	• System Expansion	• Many agencies have turned off their automated incident detection algorithms because of timeliness and accuracy issues. Agency must be willing to calibrate detection algorithms and have realistic understanding of performance.
Potential Performance Measures	• Improved system operations	• Reduction in average detection time • Reduction in average verification time • % change in correct incident detections

		• Decrease in the % of false detection and alarms
	• Improved safety	None Identified
	• Improved customer satisfaction/relations	• Improved public perception of reduction in arrival times of response personnel
	• Improved agency efficiency	• Reduction in operator workload
	• Reduced vehicle emissions and fuel consumption	• % reduction in vehicle emissions attributed to rapid detection of incident conditions
	• Promote multimodal operations	None Identified
Data Requirements	• Primary	• Available incident detection sources • Current detection times by incident detection sources • Incident frequencies and duration by facilities
	• Secondary	• Loss of system capacity due to incidents • Traffic demands
Relationship to Other Systems	• Surveillance and Detection	• Requires significant surveillance infrastructure which carries on initial cost and ongoing maintenance considerations

Incident Clearance • Processes and procedures adopted by agencies to ensure the rapid removal of vehicles, wreckage, debris, spilled material and other items from the roadway and the immediate area of an incident to restore roadway capacity. • Example include the following: On-site clearance planning, tow trucks and heavy-duty wrecker contracts, service patrols, accident investigation sites, and quick clearance policies		
Spatial Analysis Needs	• Facility Level	• Identify the incident response resources available on facilities
	• Corridor Level	• Develop and assess diversion and response plans
	• Regional Level	• Identify agreements on interagency communication strategies • Assess the need for and the effectiveness of joint operations, mutual-aid, and quick clearance agreements • Identify the need for quick clearance legislation and policies
Temporal Analysis Needs	• Present Day	• Assess the current response times of various response agencies
	• Intermediate	• Assess the opportunities for integrating computer aided dispatch and traffic management software systems
	• Long-Range	• Assess the effectiveness of improved interagency cooperation on the overall response process
Policy Needs / Operating Philosophy	• Adoption of quick clearance policies	• Establishment of incident clearance goals and objectives • Operation and function of transportation management center • Traveler information dissemination policies
Issues Affecting Implementation	• Integration	• Integration of public safety Computer Aided Dispatch (CAD) and TMC data systems. TMC automatically alerted to location of incident as it is being reported to emergency services. Verification and response can begin much sooner.
	• Interagency communications	• Intra- and interagency communications has historically been an issue. This includes voice radio interoperability, data, and video links between public safety communication center (CAD systems), TMCs, and highway operations centers.
Potential Performance Measures	• Improved system operations	• Reduction in average response time • Reduction in average clearance time • Increase in number of incidents to which response was initiated • % of major incidents cleared within 90 minutes • % of minor incidents cleared within XX minutes • % of lane blockages cleared in XX minutes
	• Improved safety	• Reduction in the occurrence of secondary incidents • Reduction in exposure time for emergency responders to traffic
	• Improved customer satisfaction/relations	• % of incidents where travelers where warned with 5 minutes • Improvement in travel time and travel time reliability
	• Improved agency	• Improvement in the uniformity, quality, and timeliness of incident and delay-related data

	efficiency	• Reduction in the time required to identify and secure equipment resources for traffic management activities • Reduction in average time delay in the dispatching of appropriate response equipment and personnel
	• Reduced vehicle emissions and fuel consumption	• Increase in fuel savings benefits due to incident management
	• Promote multimodal operations	None Identified
Data Requirements	• Primary	• Current response and clearance times by incident type and facility • Average incident durations • Types and scope of quick clearance policies
Relationship to Other Systems	• Ramp Metering • Traveler Information • Traffic Management Center	• Ramp metering can be used also to manage flow in and around incident locations • Traveler information systems are used to manage demand and encourage diversion away from incident scene. • TMCs provide a location where traffic management strategies can be coordinated.

Transportation Management Control Centers • Serves as focal point of control and management infrastructure • TMC not only physical entities (such as building and infrastructure), but also staffing to support multiple transportation management functions (i.e., dispatchers, operators, & support personnel) • Controls, monitors, and manages elements of transportation system, including surface street, highway, transit, bridges, and tunnels • TMC works with field hardware, communications equipment, and policies and procedures to deal with various transportation-related events that impact system		
Spatial Analysis Needs	• Facility Level	• Assess detection and surveillance capabilities • Assess communications needs
	• Corridor Level	• Identify management and control goals and objectives • Identify potential diversion routes during incident conditions • Determine potential resource sharing opportunities
	• Regional Level	• Develop standard procedures and policies for operating and managing the transportation system during different traffic scenarios • Identify the needs for interagency cooperation and agreements.
Temporal Analysis Needs	• Present Day	• Determine hours of operation of control center. TMCs may be operated only during special events, peak-periods, or 24hr/7day a week. • Assess communication needs of existing and proposed functions
	• Intermediate	• Evaluate the economies of scale of combining various traffic management functions
	• Long-Range	• Assess the effectiveness of joint operations and the need to share information with other entities • Assess the opportunities to provide improved emergency management and statewide traffic management capabilities
Policy Needs / Operating Philosophy	• Joint Operations	• Assess the implications of joint operations on staffing, information and resource sharing, improved incident response and clearance times, and redundancy in systems, functions and personnel among various agencies
Issues Affecting Implementation	• Combination of functions	• Analysis tools need to be able to identify when there are enough traffic management activities being performed in a region to justify expense of building physical facility.
	• Staffing	• Staffing a TMC requires more than just operators to work control room floor. Other staff includes the following: managers and supervisors; computer software and hardware support personnel, communications specialists and operators, electronic and maintenance technicians, and administrative support (budgeting, purchasing, etc.)
Potential Performance Measures	• Improved system operations	• % change in congested highway miles • % change in travel time index • % reduction in travel time variability

	• Improved safety	• % change in miles of high accident locations • Reduction in crash frequencies and rates
	• Improved customer satisfaction/relations	• % of travelers arriving at their destinations within an acceptable time
	• Improved agency efficiency	• % reduction in duplicated functions and staff among multiple agencies • % reduction in costs for system management
	• Reduced vehicle emissions and fuel consumption	• % reduction in vehicle emissions • % reduction in fuel consumption
Data Requirements	• Primary	• Number of centerline- and lane-miles of facility under control of TMC • % of facilities covered by various traffic management functions • Number of staff and hours of operations to perform various traffic management functions • Number of agencies and areas involved in providing various traffic management functions
Relationship to Other Systems	• Transit Fleet Management • Traffic Signal System	• The TMC is the focal point of the control and management infrastructure. It facilitates reception of data, coordination of response, and cooperation among different transportation and emergency entities in a region.

Collision Avoidance Systems

- Use sensors to monitor vehicle movements and driver behavior patterns to detect and assist motorist in either avoiding a collision or lessening the likelihood of a serious bodily injury occurring as a result of the vehicle being involved in a collision. This is done by using one of more of the following methods:
  - Modifying the vehicle's operation directly as needed to avoid a dangerous situation;
  - Issue warning to the driver to take corrective action; and
  - Make adjustments to safety devices (such as seatbelts, airbags, suspensions, steering systems and brakes) in anticipation of a collision.
- Three general types of collision avoidance systems:
  - *Longitudinal collision avoidance systems* – addressing rear-end and backing related collisions that occur when vehicle follow too close or when vehicle is backing in close proximity to an object.
  - *Lateral collision avoidance systems* – addressing collision caused when a vehicle either crashes into a roadside object as a result of running off the road; or crashes head-on or in a sideswipe manner with another vehicle.
  - *Intersection collision avoidance systems* – addressing right-angle and other types of collision occurring at intersections.
- With the exception of intersection collision avoidance systems, most of these systems are deployed by the private automobile manufacturers and there is not much that public agencies can do to influence rapid product development and deployment.

Spatial Analysis Needs	• Facility Level	• Some research and product development associated intersection collision warning systems has occurred. These include vehicle-actuated warning signs, and modifications to signal control if the potential for collision is detected. These are systems that can be deployed by public agencies. It is likely that the deployment of these systems will occur first at high-accident locations and then become more widespread as controllers at intersections are replaced. Analysis tools would be to estimate the reduction in collisions by type at individual intersections. • Assess the types of collisions occurring at intersections and identify high accident intersections • Investigate the potential to install equipment at traffic signals to modify signal timings (i.e., length clearance interval or hold green phases) if vehicle expected to infringe on intersection.
	• Corridor Level	• Assess the potential of using collision avoidance system to improve work zone safety in a corridor.
	• Regional Level	• Generally, significant market penetration of these systems will not occur until the vehicle fleet is turned over. This will result will be a gradual, widespread, regional-based process. • Assess potential to reducing vehicle/pedestrian right-angle collisions at intersections.
Temporal Analysis Needs	• Present Day	• As discussed above, some intersection collision warning systems can be deployed in the relative near-term. Some of these systems will most likely occur at high-accident locations first. • Assess intersection locations that could potentially benefit from infrastructure-based

		(non-vehicle bases) collision avoidance systems • Investigate the potential to install equipment at traffic signals to modify signal timings (i.e., length clearance interval or hold green phases) if vehicle expected to infringe on intersection.
	• Intermediate	• Because these systems are generally available on higher-priced vehicles, significant market penetration might occur in the more affluent sub-regions in an area in near future. • Assess the potential of equipping public agency and transit fleet vehicles (especially buses and light-rail vehicles) with collision avoidance/warning systems
	• Long-Range	• Widespread deployment of these systems will not occur until a significant portion of today's vehicle fleet is turned over 15-20 years from now. • Assess long-term costs of deploying the systems on fleet vehicles.
Policy Needs / Operating Philosophy	• Deployment of technology	• Public agencies can do little to influence the development and deployment of in-vehicle collision avoidance systems, except on public fleet vehicles. Public agencies could potentially improve safety by deploying this technology on public fleet vehicles. • Intersection collision avoidance systems that do not require in-vehicle deployments can be installed to reduce crash frequencies and/or severities at specific point locations.
Issues Affecting Implementation	• Cost of adoption	• Most of these systems are largely being offered by original equipment manufacturers as autonomous packages. Because these systems are generally options on new vehicles, widespread deployment will require an on-going investment in replacing the current automotive and public service fleets.
	• Legal	• Liability and operational issues due to false alarms and driver over-reliance on alarms or assistive systems. • System may not fully function or adequately correct for inclement weather.
Potential Performance Measures	• Improved system operations	• Increase in capacity as a result of vehicles now traveling closer together
	• Improved safety	• Reduction in accident frequency and rates for each collision type • Reduction in fatalities, injuries and property-damage collisions • Cost savings to society as a results of reduction in collisions
	• Improved customer satisfaction/relations	None Identified
	• Improved agency efficiency	• Reduction in fleet vehicle downtime and maintenance due to decreased number of crashes • Reduction in intersection equipment replacement costs due to decreased number and/or severity of crashes
	• Reduced vehicle emissions and fuel consumption	None Identified
Data	• Primary	• Projected market penetration over time

Requirements		• Reduction in accident rates / types correlated for various market penetration levels • Current /projected crash frequencies and rates at intersection and in system as whole over time
Relationship to Other Systems	• Transit Fleet Management • Traffic Signal System	• Precision docking for automated buses • Dynamically altering signal clearance interval when detection collision threat

Pre-Trip Information • Uses technology to provide information to travelers about current traffic and transit conditions so that they can make informed route-choice, mode, and departure time decision before beginning a trip. • Objective is to provide real-time, customized information that travelers can use to assess different travel options. • Numerous technologies are being used to provide this information, including radio, television, telephones, internet sites, kiosks, etc. • Displays real-time speed, traffic, congestion information to travelers.		
Spatial Analysis Needs	• Facility Level	None Identified
	• Corridor Level	• Assess the factors that might influence route and mode choice decisions, such as availability of and access to travel alternatives (i.e., parking availability).
	• Regional Level	• Assess the types of travelers in a region and identify potential market segments or user groups
Temporal Analysis Needs	• Present Day	• Assess impacts on customer satisfaction and customer relations.
	• Intermediate	None Identified
	• Long-Range	• Some private entities are providing value-added features to information provided by public sector. Determine how coupling value added information with public sector data might change travel responses.
Policy Needs / Operating Philosophy	• Customer service vs. operational improvement	• These types of systems are not likely to have a measurable impact on congestion levels. Many agencies provide these types of systems as a customer service to improve customer relations or agency image. If implemented, agencies need to realize that they will have difficulty justifying them based on benefits to operations.
Issues Affecting Implementation	• Lack of consistent evaluation results	• Some past evaluations have suggested that pre-trip information has not had a measurable effect on traffic congestion, transit usage, and air quality. Others have shown significant changes in travel behavior as a result of these systems. Regional effects of these types of systems are difficult to measure.
Potential Performance Measures	• Improved system operations	None Identified
	• Improved safety	None Identified
	• Improved customer satisfaction/relations	• Performance measures should be focused on individual trip pattern changes. Example might include the following: • Number of times weekly pre-trip information systems are accessed. • % of individual requested information on two or more alternative routes, • % of individuals stating they altered trip departure time, mode, and/ or route as result of receiving information • % of region covered by various information dissemination outlets • % of users reporting lower levels of anxiety as a result of accessing information

		• % of users reporting that they save time, avoided congestion, or arrived on time after accessing information.
	• Improved agency efficiency	None Identified
	• Reduced vehicle emissions and fuel consumption	None Identified
Data Requirements	• Primary	• Number of trips by origin-destination pair • % of trips influenced/changed by pre-trip information • Understanding of driver behaviors in response to different types of information • Understanding of the availability of different information dissemination capabilities
Relationship to Other Systems	• Special Event Management	• Information dissemination through media and other outlets is important function of special event management. These systems could be used to provide information about travel options, parking, etc. for special events.

En-Route Transit Information Systems • Systems that provide information to transit users after their trip have started. • Type of information provided by these systems include arrival and departure times, information on transfers and connections, information other regional transportation services, and information on related services, such as park-n-ride availability. • Information can be provided on-board transit vehicles, at transit stops or transit centers, or at park-n-ride lots. • Primary target of information is transit users.		

Spatial Analysis Needs	• Facility Level	• Examine the design and placement of specific devices and technologies to be deployed. Example would include the following:
		  • Design and placement of information systems located at transit stops (i.e., next vehicle arrival time)
		  • Design and placement of route information displays and kiosks
		• Identify site specific information needs, such as parking availability, trip times, intermodal transfer times and locations, route choices, etc.

	• Corridor Level	• Identify communications infrastructure necessary to support en-route information • Determine update intervals for available information
	• Regional	• Assess the impacts of pre-trip information on traffic operations need to be analyzed at a regional level. There is evidence suggesting that at level of an individual, real-time pre-trip information had an impact on travel decisions, but there is little data available on a regional basis. • Identify of integration requirements with other systems to supply regional data • Assess potential market impact and associated user/system benefits.
Temporal Analysis Needs	• Present Day	• Assess impacts on customer satisfaction and customer relations. • Assess current capabilities of en route transit information systems • Identify potential customer markets not currently being service
	• Intermediate	None Identified
	• Long-Range	None Identified
Policy Needs / Operating Philosophy	• Customer service vs. operational improvement	• These types of systems are not likely to have a measurable impact on congestion levels. Many agencies provide these types of systems as a customer service to improve customer relations or agency image. If implemented, agencies need to realize that they will have difficulty justify based on benefits to operations.
Issues Affecting Implementation	• Information Delivery	• There is a close correlation between target audience and delivery mechanism. For example, interactive kiosks may not be useful to regular users of transit system, but first time users or user going to different destinations found kiosks useful. • Real-time information (for example: next vehicle arrival time information) is much better than static information.

Potential Performance Measures	• Improved system operations	None Identified
	• Improved safety	None Identified
	• Improved customer satisfaction/relations	• Performance measures should be focused on customer satisfaction. Examples might include the following: • Changes in user perceptions and attitudes toward quality of service • Comparison of perceived versus actual wait times • Increases in reliability and credibility of information
	• Improved agency efficiency	None Identified
	• Reduced vehicle emissions and fuel consumption	None Identified
Data Requirements	• Primary	• % of transit routes already covered by en-route transit information services • Survey of customer satisfaction ratings of current en-route transit information services and how they can be improved. • Schedules of transit vehicles • Location of transit system transfer points
Relationship to Other Systems	• Transit Vehicle Tracking System	• Users preferred real-time information over static information. In order to provide real-time vehicle arrival information, agencies need to be able to determine location of transit vehicle and monitor its trip.

<table>
<tr><th colspan="3"><u>En-Route Driver Information Systems</u>

These are technologies used to provide traffic and travel information to drivers when they are already en-route to their destination.
The type of information usually communicated to drivers through these devices includes the following: traffic and travel time conditions, incident locations, construction activities; hazardous round conditions, and safe speeds.
Devices commonly used to provide this type of information can be grouped into two categories:

Agency-owned – which includes dynamic message signs (DMSs) and highway advisory radios (HARs); and
Privately-owned – which includes commercial radio broadcasts, personal communication devices (such as pagers, cellular telephones, personal digital assistants); and in-vehicle navigational systems.

The manner in which the information is delivered is important because it affects the assessment needs.
</th></tr>
<tr><td rowspan="3">Spatial Analysis Needs</td><td>• Facility level</td><td>• Assess the effectiveness of agency-owned devices, such as DMSs and HARs, installed at regular intervals along a facility in a corridor to encourage diversion in response to incidents.
• Determine the locations in the corridor to install agency-owned devices to maximize opportunities for route diversion.</td></tr>
<tr><td>• Corridor Level</td><td>• Assess the effectiveness of agency-owned devices to provide incident and route-choice information to motorists near the affected travel area specific to the corridor.</td></tr>
<tr><td>• Regional</td><td>• Compare the effectiveness of agency-owned devices to privately-owned devices to effect route-choice and diversion farther on a more regional basis.</td></tr>
<tr><td rowspan="3">Temporal Analysis Needs</td><td>• Present Day</td><td>• Determine the effectiveness of different mediums to provide traffic and travel information to drivers when they are already en route to their destination.
• Assess the potential populations reached by agency-owned devices</td></tr>
<tr><td>• Intermediate</td><td>None Identified</td></tr>
<tr><td>• Long-Range</td><td>• Market for communication devices is pretty much saturated; therefore, potential for market growth of handheld devices limited. Assess the long-term growth potential in services that will provide traffic and travel updates via handheld.
• Correlate growth projections for these services probably with growth projections for in-vehicle navigation systems.</td></tr>
<tr><td>Policy Needs / Operating Philosophy</td><td>• Charging fee for information</td><td>• Many agencies have a desire to generate revenue by charging a fee for information provided to third-party information service providers. An assessment is needed to examine the financial and legal ramifications of charging for that information.</td></tr>
<tr><td>Issues Affecting Implementation</td><td>• Information Credibility</td><td>• Credibility and message clarity are important if these types of devices, especially agency-owned devices, are to have an effect on drivers' behavior. Less information or no information at all is better than incorrect information. Public agencies cannot control timeliness and accuracy of message broadcast on private systems.</td></tr>
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	• Message Design	• Messages that provide specific instructions are more likely to cause drivers to change their behavior than messages that simple describe a situation. Many transportation agencies, however, are hesitant to place messages with specific instructions for fear of liability and political concerns.
Potential Performance Measures	• Improved system operations	• It is difficult to measure the benefits of these types of devices, especially when used in non-recurring situations, because there is no control to which to compare the results. Generally their impact on traffic is too small to be measurable by conventional techniques.
	• Improved safety	None Identified
	• Improved customer satisfaction/relations	None Identified
	• Improved agency efficiency	None Identified
	• Reduced vehicle emissions and fuel consumption	None Identified
Data Requirements	• Primary	• Detailed cost data for devices already available • Limited information on effectiveness data on amount of diversion caused by devices during incident conditions. With most incidents, more than one traffic management technique is deployed at time, so it is difficult to isolated effectiveness of information system.
Relationship to Other Systems	• Surveillance and detection system	• Because of credibility issues, those agencies that have better surveillance and detection capabilities are more likely to be willing to post specific diversion information. Agency less likely to recommend diversion to alter facilities if they do not have information about status of those facilities to which they are diverting traffic.

Route Guidance Systems • These systems are intended to enable a driver to determine the best route that most closely matches a desired criterion: shortest path distance, fastest time, or least congested. • These systems can be static or dynamic. With static systems, travel routes are generally computed based on historical information. With dynamic system, real-time information about traffic and travel conditions is used to compute a path from the vehicle's current location to its destination. Dynamic route guidance systems require a communications system to receive updated traffic and travel information as well as system for locating the vehicle within the network. • Some of these systems provide turn-by-turn instructions to assist motorists in finding their way to their destination. • Some systems also provide "yellow page" and points of interest information as well.		
Spatial Analysis Needs	• Facility Level	None Identified
	• Corridor Level	None Identified
	• Regional Level	• Assess the potential to deploy this technology of public sector and emergency services fleet vehicles. Deployments are not constraints to a facility or corridor, but can be deployed throughout a metropolitan area. Most of these systems are internal to the vehicle.
Temporal Analysis Needs	• Present Day	• Determine how drivers react to the information so that more accurate assessment of the impacts of route guidance and other traveler information systems.
	• Intermediate	None Identified
	• Long-Range	• Estimate the market penetration of these systems in their region over time. This will allow them to better estimate the effects of these systems on traffic operations.
Policy Needs / Operating Philosophy	• Safety and Human Factors	• Numerous human factors issues still need to be addressed concerning the functionality and safety of route guidance systems, especially as market penetration increases. Ease of use and safety are closely linked.
Issues Affecting Implementation	• Private sector deployment	• These systems are primarily being installed through the private sector. It is unknown at this time if these systems will achieve widespread deployment and market penetration.
	• Public sector deployment	• Public sector deployments of the technology most likely to occur in demand responsive transit vehicles and emergency service vehicles. Majority of public sector costs involved in installing surveillance and detection systems to support inclusion of real-time traffic and travel information into routing algorithms.
	• System Design	• Most modern route guidance systems rely on sophisticated location and navigation technologies. For these to function properly, they must have access to a large volume of accurate, and timely traffic and road condition data in real-time. They must also

		have a robust, stable architecture and be able to interact seamlessly with numerous different components.
Potential Performance Measures	• Improved system operations	None Identified
	• Improved safety	None Identified
	• Improved customer satisfaction/relations	These performance measures would be for public agencies vehicles equipped with route guidance systems: • Improvement in on-time pickups (dynamic transit systems) • Reduction in trip travel time • Improvement in response times (emergency services)
	• Improved agency efficiency	These performance measures would be for public agencies vehicles equipped with route guidance systems: • Reduction in fuel consumption (dynamic transit systems) • Average # of passengers per trip (through better trip chaining) • Change in vehicle miles traveled
	• Reduced vehicle emissions and fuel consumption	None Identified
Data Requirements	• Primary	• % of vehicles equipped with route guidance systems • Quantification of driver responses to information (% of trips diverted due to traffic information, etc.)
Relationship to Other Systems	• Automatic Vehicle Locating Systems • Surveillance and Detection	• These systems are closely linked to AVL and surveillance and detection systems. Route guidance systems require that vehicles be accurately located on the network. For dynamic routing, accurate and timely traffic and travel information required.

Traveler Information / 511 Systems
• These systems include a wide ranges of services and systems that are intended to provide information to travelers in a region
• The types of information that are included in these systems include the following:
  • Road and weather condition information,
  • Point-to-point route planning,
  • Location of key servicing areas (i.e., transit stations, tourist centers, etc.),
  • Transit alternatives,
  • Special event information, and
  • Camping information
• These services can be web-based or telephone-based. A 511 call center is an example of a telephone-based traveler information system.		

Spatial Analysis Needs	• Facility Level	None Identified
	• Corridor Level	• Identify and assess the information needs of traveler at key service areas and special event generators
	• Regional Level	• Identify sources of information that can be used to provide region-based information to travelers on a wide-range of transportation related options.
Temporal Analysis Needs	• Present Day	• Estimate and assess travelers' demand for information by time of day, day of week, and monthly
	• Intermediate	None Identified
	• Long-Range	• Assess the rate of growth in usage of system over the long-term. Agency will need to be able to track and make predictions of the system usage over time. Agencies will also want to be able to determine how usage of the system changes with different events (such as severe weather events, major special events, etc.) Furthermore, agencies might want to use theses predictions to help them assess long-range or special event staffing needs.
Policy Needs / Operating Philosophy	• Customer service vs. operational improvement	• These types of systems are primarily intended to be a customer service and not an operational improvement. While drivers may change their individual trip patterns, it would be difficult to quantify the cumulative effects of all these individual changes.
Issues Affecting Implementation	• National Standards	• One of the reasons for adopting "N11" number for this service is so that travelers, regardless of their hometown, have a nationally-recognized number through which they can get traffic and travel information. Efforts are currently underway to develop "standards" for the types of information to be available through these services so that travels can get consistent information anywhere in the United States. The same issue is true for in-vehicle traveler information system as well.

Potential Performance Measures	• Improved system operations	None Identified
	• Improved safety	None Identified
	• Improved customer satisfaction/relations	• What users like, dislike, etc. • Desired service enhancements • Demographics (e.g., age, location, mode, etc.)
	• Improved agency efficiency	• Change in call volumes • Usage patterns by type of content, time of day, day of week, etc. • Correlation of call volume with bad weather, events, holidays • Change in content quality, such as accuracy of road closures, timeliness of incident information • % improvement in system reliability & availability • Change in call duration • Change in cost of service: operating costs, and capital investment
	• Reduced vehicle emissions and fuel consumption	None Identified
Data Requirements	• Primary	• These systems are region-based as they provide information to travelers on a wide-range of transportation related options. As systems and the type of services they provide can range greatly from location to location in the United States, it would be difficult to quantify the effects these system would have on traffic operations. To assess potential benefits of system, agencies need information from similar systems deployed in similar sized locations providing similar services to those proposed in the area.
Relationship to Other Systems	• Traffic Management • Incident Detection • Transit Information Systems • Weather information systems	• These systems provide travelers with a vital service by keeping them informed about their travel options. Because these systems can be used to encourage diversion, route-choice, and mode-choice decision, they are often viewed an essential part of the transportation management functions in a region.

REFERENCES

1. *Linking Regional Planning and Operations for Effective ITS Deployment.* Proceeding from the 21st Century Transportation Infrastructure Symposium. Sponsored by the Federal Highway Administration, Federal Transit Administration, and the Volpe National Transportation System Center. Washington, D.C., December 16-17, 1996.

2. National Summit on Transportation Operations

3. *Getting More By Working Together – Opportunities for Linking Planning and Operations*. Federal Highway Administration, U.S. Department of Transportation. Washington, D.C., 2005. Available at

4. W. Berman, M. Smith, and J. Seplow. *Regional Transportation Operation Collaboration and Coordination: Working Together for Safety, Reliability, and Security*. Presented at 2003 ITE Annual Meeting, Seattle, WA. August 2003.

5. S. Gayle. *Looking at Transportation Planning With an Operations Perspective*. Presented at 2003 ITE Annual Meeting, Seattle, WA. August 2003.

6. A. Pagano, S. McNeil, E. Ogard, and T. Group. *Linking Asset Management to Strategic Planning Processes: Best Practices from State DOT's*. Presented at the 84th Annual Meeting of the Transportation Research Board. TRB, National Research Council, Washington, D.C., January 2005.

7. P. Noyes. *The Key Principles of Linking Planning and Operations.* Present at the 2003 ITE Annual Meeting, Seattle, WA. August 2003.

8. *AMPO Survey Results: Planning and Operations.* Association of Metropolitan Planning Organizations. Available at http://www.ampo.org/ Accessed December 17, 2005.

9. 2005-2008 Transportation Improvement Program for the Twin Cities Metropolitan Area. Available at http://www.metrocouncil.org/planning/transportation/TIP/tip2005_2008.htm

10.

11.

12. *http://www.bcsmpo.org/pdffiles%20on%20www.bcsmpo.org/04-06TIP%20Amendment.pdf*

13. 2004-2008 Transportation Improvement Plan for the Baltimore, MD Region. Available at http://www.baltometro.org/TIP/TIP2009final.pdf.

14. FY 2005-2010 TIP Handbook. Atlanta Regional Commission. December 2003. Available at http://www.atlantaregional.com/transportationair/tip.html) Accessed January 21, 2005.

15. *Policy on Transportation Improvement Program (TIP) Preparation. Guidance for preparing the 2005-2010 TIP*. Denver Regional Council of Governments. Available at

16. *Appendix B – Project Development*. *2004-2006 Transportation Improvement Program.* Houston-Galveston Area Council. Available at http://

17. Fiscal Years 2004 Through 2007 Special Maricopa Association of Governments Transportation Improvement Program Volume II—Technical Report. Available at http://www.mag.maricopa.gov/pdf/cms.resource/FY04-07-TIP-Reports 11-25-0385902.pdf.

18. 2004 STP/CMAQ Regional Competition. Puget Sound Regional Council. Regional Project Evaluation Criteria. Available at http://www.psrc.org/projects/tip/selection/2004/2004rpc.htm.

19. *Appendix G – Selection of New Projects.* Capital District Transportation Commission. Albany, New York. Available at http://www.ccdtcmpo.ort/tipdoc03/appg.html

20. Institute of Electrical and Electronics Engineers. *IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries.* New York, NY: 1990.

21. National ITS Architecture Version 5.0 Available at http://www.iteris.com/itsarch/index.html.

22. California Center for Innovative Transportation Website http://calccit.org/itsdecision/serv_and_tech.html)

23. Freeway Management Handbook. FHWA. Available at

24. *Managing Travel for Planned Special Events Handbook*. FHWA. Available at http://ops.fhwa.gov/program_areas/sp_event_mgmt/ handbook/chapter3_05.htm.

25. *Managing Travel for Planned Special Events Handbook*. FHWA. Available at http://ops.fhwa.gov/program_areas/sp_event_mgmt/ handbook/chapter3_05.htm.

26. *Resource 511* Webpage. Available at http://www.deploy511.org.

27. *Assess Performance and Customer Satisfaction.* Presentation by Carol Zimmerman at *511* Workshop, November 2002. Available at http://www.deploy511.org/usage.htm.

28. *511: America's Travel Number* Webpage. Available at http://www.its.dot.gov/511/511ver2.htm#_Toc50757171.

APPENDIX A.

Final Participants List

User Needs for Integrating and Evaluating ITS and Operations in the Planning Process

Name	Organization	Agency Type	Location
Eric Hill	MetroPlan Orlando	MPO	Orlando, FL
John Ward	Delaware Valley Regional Planning Comission (DVRPC)	MPO	Philadelphia, PA
Salvador Gonzalez	El Paso MPO	MPO	El Paso, TX
Natalie Bettger	North Central Texas Council of Governements (NCTCOG)	MPO	Arlington, TX
Krista Jeanotte	Cambridge Systematics	Tool Developer (IDAS)	Oakland, CA
Jim Dale	PTV America, Inc	Tool Developer (VISSIM)	Corvallis, OR
Marc Hansen	Mid-America Regional Council	MPO	Kansas City, MO
Lisa Klein	Metropolitan Transportation Commission	MPO	San Francisco, CA
Phil DeCabooter	SmartWays, Wisconsin DOT	Operations	Madison, WI
Jesse Gwilliams	Michigan DOT	Planning	Lansing, MI
Hani S. Mahmassani	Maryland Transportation Initiative	Tool Developer (DynaSmart)	Maryland
Bill Tansil	Michigan DOT	Planning	Lansing, MI
Vassili Alexiadis	Cambridge Systematics	Tool Developer (IDAS)	Oakland, CA
Martin Fellendorf	PTV America, Inc	Tool Developer (VISSIM)	Corvallis, OR
Kevin Balke	Texas Transportation Institute	Research	College Station, TX
Penelope Weinberger	Texas Transportation Institute	Research	Washington, D.C.
Harlan Miller	Federal Highway Administration	Federal DOT	Washington, D.C.
Henry Liu	Federal Highway Administration	Federal DOT	Washington, D.C.
John Halkias	Federal Highway Administration	Federal DOT	Washington, D.C.
Wayne Berman	Federal Highway Administration	Federal DOT	Washington, D.C.
Brian Gardner	Federal Highway Administration	Federal DOT	Washington, D.C.

APPENDIX B.

One-Day Workshop on

User Needs for Integrating and Evaluating ITS and Operations in the Planning Process

January 13, 2005

Marriott Wardman Park, the North Carolina Room
2660 Woodley Park, NW, Washington D.C. 20008
Ph. 202-328-2900

8:15-8:30	*Overview and Introductions*
<u>Moderator: Harlan Miller, FHWA</u>	
	Moderator will provide a quick overview of the purpose for the workshop and discuss agenda for workshop. Moderator will also take care of "house cleaning issues (restrooms, breaks, lunch, etc.) We will then go around room with self introductions.
8:30-9:30	*Planning for ITS and Operations Project*
<u>Moderator: Harlan Miller, FHWA</u>	
	This session will have three speakers to discuss their perspective of how the planning process is used to identify and program ITS and operations in their area. Each speaker will be asked to discuss the analysis tools that they use.
<u>Potential Speakers:</u>	
	State DOT Perspective: Phil DeCabooter, Wisconsin DOT MPO Perspective: Natalie Bettger, North Texas Council of Governments, Arlington, TX MPO Perspective: Lisa Klein, Metropolitan Transportation Commission, Oakland, CA
9:30-10:00	Open Discussion of Planning Process
10:00-10:15	Break
10:15-11:30	*Use Cases: Planning Operational Projects*
<u>Moderator: John Halkias and Wayne Berman FHWA</u>	
	This session will be a panel discussion. We will give each speaker a list of questions that we would like to have specially addressed in their presentation. Example of questions include the following: How are operational projects identified? Who decides them? How are projects that have time frames (immediate, versus intermediate, versus long-range needs) analyzed differently? How are project with different scopes (area-wide, versus subarea, versus corridor) evaluated differently? How are projects that expand existing systems analyzed differently compared to new projects (e.g., expanding an existing versus implementing a new incident management system) ?
<u>Potential Speakers:</u>	
	Eric Hill, Director of System Management and Operations, MetroPlan Orlando, Orlando FL John Ward, Delaware Valley Regional Planning Commission, Philadelphia, PA Bill Tansil, Michigan Department of Transportation, Lansing MI
11:30-12:00	Identification of User Needs
12:00 -1:00	Lunch
1:00-2:15	*Tools for Assessing Potential Benefits of Projects*
<u>Moderator: Henry Lieu, FHWA</u>	
	The goal of this session is to begin the process of discussing the capabilities and limitation of some of the available tools. The session will begin with three speakers, each discussing some of the available tools that can be used to assess the benefit of potential projects. In this session speakers will provide a general overview of how the tools can be used to assess potential projects. Each speaker will be asked to give a quick overview of the capabilities and limitations of the product/approach.
<u>Potential Speakers</u>	
	IDAS: Krista Jeannotte, Cambridge Systematics, Inc., Oakland, CA Dynasmart-P: Hani Mahmassani, University of Maryland, College Park, MD Simulation-based Evaluation Tools: Martin Fellendorf, PTV America, Inc., Corvalis, OR
2:15 - 2:30	Break
2:30 - 3:45	Identification of User Needs and Gap Assessment of Available Tools
<u>Moderator: Kevin Balke / Gary Thomas, TTI</u>	
	In this facilitor-led session, we will ask participants to talk about the limitation of the various approaches for assessing operational and ITS projects, and identify their needs for potential improvements to these tools. We will use a consensus-building process to develop a prioritized list of improvements and needs that could potential be incorporated into various planning analysis tools.
3:45-4:00	Concluding Remarks: Summary and Next Steps